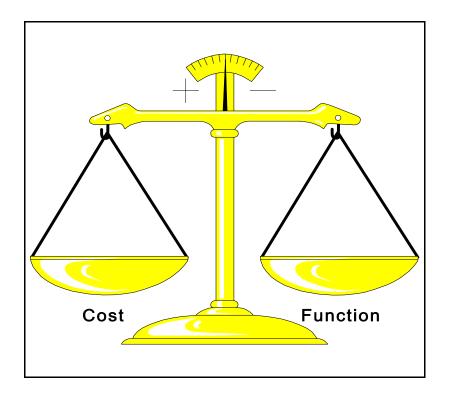
Manual of Instruction



Value Engineering

Utah Department of Transportation Engineering Services

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CHAPTER 1 INTRODUCTION

1.1 MISSION STATEMENT

To provide a quality transportation system that is safe, reliable, and serves the needs of the traveling public, commerce, and industry.

1.2 EXECUTIVE SUMMARY

The Utah Department of Transportation (UDOT) recognizes the need for the prudent use of diminishing resources and revenues while providing a quality transportation program. Value Engineering (VE) is a function-oriented technique that has proven to be an effective management tool for achieving improved design, construction, and cost-effectiveness in various transportation program elements. States that have successfully implemented a VE program have realized additional benefits beyond design and cost savings including, constant Improvement of standards and policies, accelerated incorporation of new materials and construction techniques, employee enthusiasm from participation in agency decisions, and increased skills obtained from team participation.

VE is the most effective technique known to identify and eliminate unnecessary costs in product design, testing, manufacturing, construction, operations, maintenance, data, procedures, and practices. This manual provides guidelines for the implementation and application of a VE program for UDOT.

The following are important elements of a successful VE program:

- A firm commitment of resources and support by executive management is the most important element for assuring the success of a VE program.
- 2. All levels of management understand and support VE.
- 3. A policy describes where, when, how, and to what specific areas of work the VE effort will be directed.
- 4. Every level of UDOT is trained and familiar with the VE program.
- 5. A VE Coordinator administers and monitors the VE program.
- 6. VE is performed:
 - a. Early in the planning-design process to maximize potential product improvement and cost savings.
 - b. On high-cost and complex projects.
 - c. By a multi-disciplined team of trained VE professionals.
 - d. A Value Engineering Change Proposal (VECP) program exists to encourage contractors to develop VE proposals to allow the State to benefit from a contractor's design and construction ingenuity, experience, and ability to work

through or around restrictions. Some important elements of a successful, ongoing VECP program are:

- 1) Proposal process is simple and quick.
- 2) Cost Savings are shared with the contractor.
- 3) Change proposals become the property of the State. The concept may be used on future projects.
- Change proposals do not compromise any essential design criteria or preliminary engineering commitments.
- 5) Change proposals cannot be the basis for a contract claim.
- 7. All VE team recommendations and contractor proposals are fairly reviewed and expeditiously evaluated for implementation.
- 8. VE techniques can be used to improve productivity in other areas of the State transportation program including traffic operations, maintenance, procedures and operations, standard plans and specifications, and design criteria and guidelines.
- 9. VE programs are closely monitored, evaluated, and modified to maintain effectiveness.

1.3 VALUE ENGINEERING FOR HIGHWAYS

The history of highway development is full of instances where inspiration has produced noteworthy contributions to the financial and operational betterment of highway transportation. National and State economy, with rising costs and unemployment, provide no opportunity to wait for inspiration. Value Engineering is the tool that makes things happen. It is the engineer's way to force the development and use of new ideas.

VE is based on the idea that people spend their money to accomplish functions rather than to obtain ownership. Concern for environment, energy, and rising costs, the functional needs of safe and efficient accommodation of vehicular and pedestrian traffic must be carefully and independently analyzed to obtain these functions in the most economical manner, with minimal disturbance to the environment.

1.4 DEFINITION OF VALUE ENGINEERING

VE is the systematic application of recognized techniques by multi-disciplined teams that identifies the function of a product or service, establishes a worth for that function, generates alternatives through the use of creative thinking, and provides the needed functions and reliably at the lowest overall cost. The process of VE consists of:

1. An <u>organized review</u> to improve value by using multi-disciplined teams of specialists knowing various aspects of the problem being studied.

- 2. A <u>function-oriented approach</u> to identify the system, product, or service being studied, and the associated cost.
- 3. <u>Creative thinking</u> using recognized techniques to explore alternative ways of performing the functions at a lower cost or to otherwise improve the design.

1.5 WHAT IS VALUE ENGINEERING

VE is more than just "good engineering." VE goes beyond a suggestion program and routine project or plan review. It is a new, fresh look at problems starting from basic functional requirements. Simply stated, it produces a cost reduction but does not cheapen the product or service nor does it cut corners. VE explores what other methods will accomplish the purpose of the product, service, or process we are studying?

The practice of VE includes a certain amount of expense, that must be justified by potential cost savings. Accordingly there must be a recognized need for change and a distinct opportunity for financial benefit to warrant the added cost of a VE effort.

1.6 ROADBLOCKS TO COST EFFECTIVENESS

The practice of VE does not imply that there may be intentional "gold plating," conscious neglect of responsibility, or unjustifiable error or oversight by the design team. VE recognizes that social, psychological, and economic conditions exist that may inhibit good value. The following are some of the more common reasons for poor value:

- 1. Lack of information, usually caused by a shortage of time. Too many decisions are based on feelings rather that facts.
- 2. Insensitivity to public needs or unfortunate experience with products or processes used in unrelated prior applications.
- 3. Rigid application of standards, customs, and tradition without consideration of changing function, technology, and value.
- 4. Risk of personal loss, the ease and safety experienced in adherence to established procedures and policy.
- 5. Reluctance to seek advice in specialized aspects of project development.
- 6. Negative attitudes and failure to recognize creativity or innovativeness.
- 7. Over specifying causes costs to increase as close tolerances and finer finishes are specified.
- 8. Lack of good communication, misunderstanding, jealousy, and normal friction between people are usually a source of unnecessary cost. In complex projects requiring the talents of many people, costs and functions may be duplicated.
- 9. Reluctance to make a decision inhibits creativity.

1.7 HISTORY OF VALUE ENGINEERING

VE has been applied by many private industries and local, state, and federal agencies. VE had its origin during World War II at General Electric when innovation was required because of material shortages. Some critical materials were difficult to obtain and many substitutions had to be made. Harry Erlicker, a vice president, made the observation that many times these changes resulted in lower costs and improved products. This encouraged him to seek an approach to intentionally improve a products value. He assigned Lawrence D. Miles, a staff engineer, the task of finding a more effective way to improve product value.

In 1947, Miles and his team developed a step-by-step system called Value Analysis (VA), to analyze product cost and function to eliminate unnecessary costs. As a result of substantial investment, the new methodology was developed, tested, and proven to be highly effective. In 1952 VA began its growth throughout industry.

The Federal-Aid Highway Act of 1970 made the first Federal Highway reference to VE, requiring that "in such cases that the Secretary determines advisable plans, specifications, and estimates for proposed projects on any Federal-Aid system shall be accompanied by a value engineering or other cost reduction analysis."

1.8 PRINCIPAL CHARACTERISTICS

In almost every case in which VE is applied, the money saved will be many times the cost of a VE study. Generally the expected savings ten times exceed the expected study and implementation costs.

Value Engineering is functionally oriented to include:

- 1. Identifying the function.
- 2. Placing a price tag on that function.
- 3. Developing alternative means to accomplish the function without any sacrifice of quality.

Base judgments on a total life cycle cost with strong emphasis on maintainability. Lack of VE during location, design, and construction results in higher then necessary maintenance costs.

The two main differences that distinguish VE from other cost reduction programs are:

- 1. Functional approach analysis
- 2. Systematic approach job plan.

1.9 APPLICABILITY OF VALUE ENGINEERING

Design is the smallest expenditure in project distribution costs over the life of a typical project. Usually, all of the initial costs of a project including design and construction add up to less than 50 percent of the total life cycle cost.

Figure 1 below shows which decision makers have the most influence over the total cost of ownership during the life cycle of a project. Operations and maintenance divisions have very little influence on decisions that add to life cycle costs although they are often responsible for the majority of the project's total costs. Two important things to consider:

- 1. The earlier VE is performed, the greater savings potential.
- 2. Take life-cycle costs into account during the design process.

All phases of VE consider what will accomplish the function of a system, process, product, or component at a reduced cost. Cost savings diminish as time progresses from inception to completion of a project.

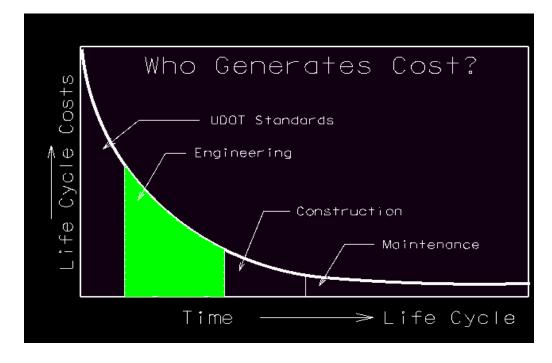


Figure 1 – Cost Creators

Creative techniques at the proper time is what makes VE effective. VE is neither a suggestion program nor a routine plan review. It is an independent approach to the project. VE entails an expense that must be justified by potential cost savings. The need for change in standards, concepts, or plans must be

recognized and a distinct opportunity for financial rewards in terms of life cycle cost savings must warrant the added project engineering cost of a VE effort.

1.10 EFFECT OF VALUE ENGINEERING

The VE goal is not to make item costs cheaper but to determine the worth of the basic function without regard to its application and set a target cost. VE finds design alternatives that meet all needs at a lower overall cost.

A VE study can generate recommendations to eliminate ten to thirty percent of the project's construction costs. The designer usually accepts about half of these recommendations, providing savings of at least five percent. The cost of the VE effort including any redesign is usually less than ten percent of the implemented savings.

1.11 FUNDAMENTALS OF VALUE ENGINEERING

The principals of VE can be applied by anyone including systems analysts, shopkeepers, engineers, or homemakers. VE is often considered a management tool to control costs. In a broader context, it is a problem-solving tool that anyone can use.

By definition and nature VE is far more than a means of reducing existing costs. VE is a tool whose strength lies in the ability to clearly delineate design alternatives and to suggest choices based on the necessity or desirability of the function, the economic availability achieving that function, and the cost-worth relationships that assures growth and prosperity.

No single phase of a VE study is apt to show anything startling to new VE team members. It is the arrangement and application of the segments of the VE methodology, use of creative techniques at the proper time, and the general philosophy that are new and unique. VE is a procedure exercise underutilized creative potential to solve problems. This is accomplished through the precise sequence of steps known as the VE Job Plan.

VE Job Plan

The VE Job Plan is shown in Figure 2. The Job Plan is an organized plan of action for VE studies.

The key features that separate the VE Job Plan from other methods used to solve routine engineering problems are:

- 1. Function analysis
- 2. Specific creative effort to develop design alternatives
- 3. Not degrading the required performance
- 4. Cost assignment for each function

The VE approach to problem solving involves function analysis followed by the application of creative thinking techniques.

The VE Job Plan phases each include multiple tasks shown in Table 1. Combining tasks and techniques with application finesse, is the art of VE. Each Value study differs enough from previous ones that a professional Value Engineer (a Certified Value Specialists) is recommended to lead the formal VE studies.

Figure 2 - VE Job Plan Phases

Value Engineering Job Plan Phases

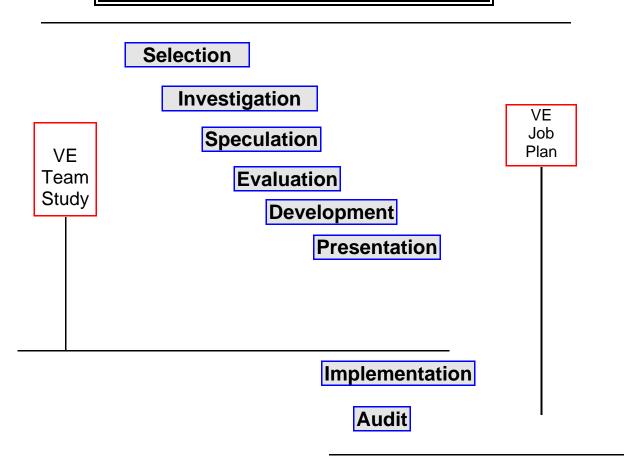


Table 1

VE Job Study Plan			
Phase Objective Key Que		Key Questions	
Selection	Select Project	What is to be Studied? Who is Best Able to Study the Problem? What must be Known to Start?	
Investigation	Investigate Project Analyze Function and Cost	What is the Project? What is the Problem? What is the Cost? What is now Accomplished? What is the Basic Function Worth? What are the Secondary Functions Worth? What are the High Cost Areas? Can Any Function be Eliminated?	
Speculation (Creative)	Speculate on Alternatives	What Else will Perform the Function? Where Else may the Function be Performed? How Else may the Function be Performed?	
Evaluation (Judgment)	Evaluate Alternatives	How Might Each Idea Work? What Might be the Cost? Will Each Idea Perform the Basic Function?	
Development	Develop Alternatives	How will the new Idea Work? How Can Disadvantages be Overcome? What will be the Total Cost? Why is the New Way Better? Will it Meet the Requirements? What are the Life Cycle Costs?	
Presentation	Present Alternative	Who Must be Sold? How Should the Idea be Presented? What was the Problem? What is the New Way? What are the Benefits? What are the Savings? What is needed to Implement Proposal?	
Implementation	Implement Alternative	Who is to Implement the Change How Will Plans/Contract be Changed? Is There Money for the Change?	
Audit	Audit Results	Did the New Idea Work? How Much did it Cost? How Much Money Was Saved? Did the Change Meet Expectations? Who is to Receive Recognition?	

Table 2

VE Job Study Plan			
Phase	Techniques	Tasks	
Selection	Solicit Project Ideas Identify High Cost/Low Value Areas Plan the Project Obtain Authorization to Proceed Allocate Resources	Speculate on Sources of Projects Develop Plan to Identify Project Analyze Projects for Applying VE Evaluate Projects for Potential Present Project to Management Select Projects for VE Study Implement Study Plan	
Investigation	Get Information From Best Sources Get all Facts and Available Costs Work with Specifics Identify the Function Challenge Everything Evaluate by Comparison Put \$ on Specs and Requirements Put \$ on Key Tolerances & Finishes Put \$ on Key Standards	Speculate on Sources of Project Data Dev. Plan to Gather Project Data Implement Data Search Plan Investigate the Project Audit Data Speculate on Functions Performed Analyze Cost Analyze Functions Evaluate Function Cost/Worth Evaluate Project Potential Select Specific Study Areas	
Speculation (Creative)	List Everything, be imaginative Use Creative Techniques Defer Judgment, don't criticize Be Courageous	Select Techniques to be Used Speculate Alternatives Select the Best Alternatives	
Evaluation (Judgment)	Weigh Alternatives Choose Evaluation Criteria Refine Ideas Put \$ on Each Main Idea Evaluate by Comparison	Speculate on Evaluation Criteria Evaluate Alternatives Select the Best Alternatives	
Development	Use Search Techniques Get Information for Best Sources, Specialists & Suppliers Consider Specialty Materials, Products & Processes Consider Standards Use New Information Compile all Costs - Work with Specifics Gather Convincing Facts	Speculate on Information Needed Speculate on Information Sources Develop a Plan of Investigation Develop Selected Alternatives Select Preferred Alternative Develop Implementation Plan Audit Data	
Presentation	Make Recommendations Use Selling Techniques Be Factual Be Brief Give Credit Provide an Implementation Plan	Develop a Written Proposal Speculate on Possible Roadblocks to Acceptance Present Recommended Alternative	
Implementation	Translate Plan Into Action Overcome Problems, Expedite Action Monitor Project	Develop Change Documents Implement Approved Alternative Evaluate Process	
Audit	Verify Accomplishments Make Awards Report to Management	Audit Results of Implementation Evaluate Project Results Present Project Results Present Awards	

To apply the VE Job Plan, two important factors must be recognized:

An effective VE effort must include all phases of the Job Plan. Omissions of any one of the phases will hamper accomplishment of the objectives. The amount of attention given to each phase will differ from one project to another.

Execution of the plan requires a team effort. The cooperation and active participation of several people produces the most effective results. Group dynamics play an important role and illustrate that results of a team of five professionals is greater that the sum of five individual efforts.

In VE, as in other problem-solving methods, a systematic approach produces better results than undisciplined ingenuity. Strict adherence to the Job Plan provides:

- 1. A process to carry the study from inception to conclusion.
- 2. A convenient basis for maintaining a written record of the effort as it progresses.
- 3. A review of facts that may have been neglected in the creation of the original design or plan.
- 4. Schedule phases that can be planned, scheduled, budgeted, and assessed.

The VE Job Plan is a systematic approach that has been used, tested, and proven to work. Experience has shown that the application of this plan produces results in reducing costs and simplifying design.

During normal cost reduction, an item is analyzed as to how to reduce the cost of the elements that make up the item. Often quality and performance are sacrificed.

Use of the VE Job Plan and its associated techniques for function analysis creative application often yields more cost reduction without adversely affecting performance. In many cases, design simplification, reliability, maintainability, and quality are improved.

Table 2 illustrates the actions required, decisions to be made, and the responsible decision-maker at key points in the Value study.

Table 3

V.E. Job Plan Points of Decision			
POINT OF DECISION	ACTION/ CONSIDERATION	DECISION	WHO MAKES THE DECISION
After the Selection Phase	Select Projects for Study. Estimate the Potential of the Study Candidates.	Decide to Proceed with Project Study	Region Preconstruction Engineer
After the Investigation Phase	Select Specific Elements Within the Project for Study	Decide to Proceed with a Study of Those Elements	V.E. Team
After the Evaluation Phase	Select Alternatives Likely to be Successful. Estimate the Potential of the Alternatives	Decide to Proceed with Development of the Best Alternative.	V.E. Team
After the Presentation Phase	Consider the Impact of the Proposed Alternative.	Decide to Implement the Proposed Alternative	Region Preconstruction Eng.
Upon Completion of the Job Plan	Review the Results.	Decide Further Program Action.	Value Engineer

The Job Plan is normally followed in sequence, phase-by-phase, as shown in Figure 3. At times it may be necessary to return to a previous phase for additional work.

The Job Plan divides the study into a distinct set of work elements. Each plan is tailored to take into account the time and resources available and the results expected.

An early step in the VE Job Plan requires those making the study to clearly define the functions performed by the item being studied. Following the Job Plan allows for time for essential creative work and the necessary evaluation to select the best design alternative.

The Job Plan produces specific recommendations necessary supporting data, required implementing actions, and a proposed implementation schedule.

Audit of VE accomplishments is necessary to provide historical supportive data to promote or improve on future designs and VE projects. The Department will realize the greatest benefits from its VE program when the process facilitates feedback into the design phase. Consider VE recommendations on individual projects as part of the normal design process.

1.12 VALUE ENGINEERING PRINCIPALS

Value Engineering principles consist of key questions, techniques, and procedural tasks used in pursuing the objective of the VE Job Plan. The objective is to achieve design excellence. VE techniques are applicable throughout the formal VE study. These techniques are significant in the area of decision making and problem solving.

<u>Create Teamwork</u> – A fundamental principal of VE is teamwork. In a complex design, with many different functions and people contributing to project cost, cost-effectiveness is enhanced when the team blends their talents toward a common objective. VE can be accomplished through concentrated individual effort. The results are magnified with teamwork.

Overcome Roadblocks – Roadblocks are obstacles in the path of progress, often occurring whenever a change is proposed. Some roadblocks are real and some are imaginary. Roadblocks are created and expressed as a resistance to change. VE techniques are designed to help overcome roadblocks

<u>Promote Relationships</u> – VE requires a high degree of cooperation amongst participants. The quality of human relations can relate directly to success or failure of the project. The effectiveness of VE effort depends upon the amount of cooperation the Engineer receives from managers, engineers, designers, and other involved in the project. Skills and techniques to help promote positive relations include:

- 1. Use a sensitive your approach
- 2. Be diplomatic resolving opposing viewpoints
- 3. Be tactful in questioning a design requirement or specification
- 4. Ask rather than demand
- 5. Suggest rather than criticize
- 6. Help rather than hinder
- 7. Show interest
- 8. Treat people honestly and fairly
- 9. Be consistent in expectations
- 10. Give credit to others
- 11. Show respect for team members
- 12. Be a good listener

These skills and techniques will be beneficial through all phases of VE. Fact finding and information sharing requires cooperation. Team member involvement is essential. Creativity flows more freely when people are properly motivated. Open minds receptive to new ideas enhance productivity.

Additional skills and techniques include?

Listen

Listen carefully to explanations concerning problems that arise. The explanations can provide clues that may save hours of investigation and research. A person who objects

to a proposal may have ideas on how it can be improved or modified.

Key Questions

The VE approach is a questioning approach. Answers are discovered when questions are asked.

Check Lists

Use questions provided in the VE Job Plan. The check lists are not all-inclusive but do provide good basic questions.

Record Everything

Do not trust your memory. During all phases of the study, record the information you have gained through interview, write down your ideas, the questions that need to be answered, and the details of your developed ideas. You will need this data in each succeeding step of the VE Job Plan and in preparing the workbook, study summary, and recommendations.

Use Good Judgment

Environmental influences often interfere with common sense and good judgment. VE often calls on philosophies such as "if it doesn't seem right, it probably isn't" or "of I wouldn't spend my money for it, it's probably not good value, and I shouldn't spend public funds for it". Value Specialists need the courage of their convictions to take action to change things that their good judgment tells them are wrong.

Quality Improvement (QI)

QI is total quality. It creates a personal and organizational culture where all employees are motivated and empowered to continuously improve all work processes, products, and services. All employees produce quality in everything they do. It is understanding and knowing, their customers. It is the Value each adds to their work. It is a way of life at UDOT that is implemented through teamwork, example, and personal involvement.

The principle of QI is based on W. Edward Deming's 14 points for management as follows:

- 1. Create consistency of purpose to improve products and services
- 2. Adopt the new philosophy
- 3. Cease dependence on inspections to achieve quality
- 4. End the practice of awarding business on the basis of price tag alone and minimize the total cost of working with a single supplier
- 5. Improve constantly and forever every process for planning, production, and service
- 6. Institute training on the job

- 7. Adopt and institute leadership
- 8. Drive out fear
- 9. Break down barriers between staff areas
- 10. Eliminate slogans, exhortations, and targets for the work force
- 11. Eliminate numerical quotas for the work force and management
- 12. Eliminate the annual rating or merit system
- 13. Institute a vigorous program of education and self-improvement for everyone
- 14. Put everybody in the Department to work to accomplish the transformation

Deming shows that quality can be achieved by establishing consistency of purpose in the Department; understanding our customers, Department, and suppliers as an integral composite system; finding problems and seeking improvements at the source in all processes and systems rather than through end-of-process inspections; forming long-term relationships with a limited number of key suppliers; and empowering people through helping, training, educating, and asking for input.

CHAPTER 2 SELECTION PHASE

2.1 OBJECTIVE

The objective of the Selection Phase is to identify projects for VE study and to select specific projects to achieve maximum monetary savings, energy savings, or other benefits, such as a shorter construction schedule. In addition, an important part of this phase is the selection of the VE team members.

Proper study selection is vital to the success of the entire VE Program. Because VE resources are limited, a major criterion in project selection is the potential benefit to be derived for the resources invested. This phase relates to the identification, evaluation, selection, planning, and authorization of study projects.

Two elements are usually present before a project is considered for a VE study.

- 1. High-cost or high-volume there must be enough potential savings to make the study worthwhile
- 2. Poor value or poor performance Reasons for poor value are discussed below.

A. Lack of Information

Failure to get sufficient relevant facts can be caused by lack of knowledge or misunderstanding of the full requirements of the original project plan and is one of the most common reasons for a VE study. Too much guessing causes insufficient information.

B. Honest Wrong Beliefs

Some decisions are based on erroneous beliefs rather than on true facts. Planners who make decisions on what a design will accomplish may not have a full sense the public need. Design decisions can also be based on wrong beliefs. Because of one unfortunate experience, either personal or through hearsay where a poor choice of material was made, a designer can become biased against the use of that material for any project.

C. Habitual Thinking

Thinking and doing things in the same way is a frequent cause of poor value. Most people have a tendency to re-use what worked the last time or to copy the standard set by others. This is a defensive measure designed to minimize risk and is promoted by management through rigid use of standard designs, procedures, customs, and tradition without consideration of changing needs or technology. Keeping up with new technology is essential in today's complex world.

D. Risk of Personal Loss

Any good engineer or manager knows that nothing is guaranteed. They also know that anything that is done over and over again contains less risk

than something new. Failure of a new approach can cause personal loss to the decision maker. Decisions are generally based on past experience of "nearly-related" data rather than on something new or unfamiliar.

E. Reluctance to Seek Advice

Designers and planners are often very reluctant to seek advice from others or admit they do not know the answer. Architects, planners, and engineers who seek the advice of competent experts will achieve maximum design value.

F. Shortage of Time

When a project appears on a long-range or annual construction program there is a critical demand that the project stay on schedule. Frequently, the time pressure is so great that it is impossible to properly consider the value of the design approach being developed. The designers usually find it necessary to accept the first workable solution to a problem in order to complete the job on time. Seldom is there time to sit back and contemplate ideas or to design for value by developing alternative approaches. Designs developed under these conditions are normally good candidates for value study work.

G. Negative Attitudes

Some designers are reluctant to make a change of any kind regardless of the merits of the proposal, especially if the change directly affects their plan or design. Others feel that they always provide for the best value in their approach. Few of the VE techniques and procedures are used in anything but a formal VE program.

H. Changing Technology

Rapid strides in the development of processes, products, and materials present constantly changing and lower cost ways, of performing the necessary functions. No one is expected to be completely current on all technology, even in their own field.

I. Strict Adherence to Requirements

Requirements and published standards are often unrealistically specified with reference to performance, materials, safety, or procedures. Sometimes requirements are assumed by the planner or designer when not specifically specified. Traditionally, designers have concentrated on developing designs that exceed all known and assumed requirements. The net result is over-design with waste of tax-payer funds. Challenge requirements to determine if they meet a need of the project or just satisfy the current standards.

J. Performance At Any Cost

When a problem is identified, the natural reaction is to develop a design that will solve the problem. This may lead to a solution with a cost that far exceeds its value. The cost of solving 95 percent of the problem may be within reason, but solving the remainder can increase the cost unreasonably. Solving 95 percent of the problem and using the remaining funds to solve other critical problems may be a more prudent approach.

K. Communication

Poor communication and misunderstanding is a frequent source of unnecessary costs. Highway projects require the talents of many people and good working relationships are a critical factor. Various specialists on complex projects not working together are likely to work at cross purposes, wasting a great deal of effort with a final product that does not have good value.

SEARCH FOR VE STUDY CANDIDATES

A concentrated effort may be necessary before suitable VE study candidates can be chosen. There are certain opportune times for Value reviews that may make the search for candidates somewhat easier.

REVIEWS PERFORMED ON PLANNING DOCUMENTS, project development and scheduling, budget submittal, and expenditure distributions.

ESTABLISHED DESIGN REVIEW POINTS, such as the reviews conducted after public hearings (location, design, or both).

THE INTRODUCTION OF NEW PRODUCT INFORMATION from suppliers, seminars, and conferences often provides the opportunity for Value reviews of existing designs and standards.

2.2 CANDIDATE SOURCES

Techniques to find study candidates might include some or all of the following:

APPOINTMENT OF A VALUE REVIEW TEAM to study a particular project. Such a team should consist of three or four members who understand the various aspects of the design.

A STANDING REVIEW COMMITTEE meeting periodically to make recommendations should be made up of key people from planning, design, construction, traffic operation, and maintenance or operations branches depending on the item being studied. Studies conducted on these suggestions usually would have an excellent chance for acceptance because the committee members would include some of the same people who would be passing judgment on the recommended changes.

SOLICITATIONS FOR INTRA-DEPARTMENT OR INTER-DEPARTMENT SUGGESTIONS to obtain "grass root" suggestions, often offer many good ideas from which to choose.

PAST SUGGESTIONS AND FALL-OUT FROM PREVIOUS STUDIES are sources that should not be overlooked.

THE UDOT APPROACH is for the Value Engineer to attend all concept meetings where the projected project costs are greater than \$2 million. Based on the project concept the Value Engineer, with the support of the District Preconstruction Engineer selects project that will benefit from a Value Engineering Analysis. The study can then be performed in two different phases; 1) while the project is still in the Concept Phase, or 2) during the project Design Phase, as shown in UDOT Procedure 08-1.

2.3 PROJECT IDENTIFICATION TECHNIQUES

One technique used in project identification is a method called Relative Cost Ranking. The relative ranking method relates to Pareto's Law, developed early in the twentieth century by Vilfredo Pareto. He studied the concentration of wealth and income in Europe. He found that 80 percent of the total national income was concentrated to about 20 percent of the population.

In the Value Engineering application, Pareto's Law is used to show that the most costly items of a given project normally constitute a relatively small percentage of the total number of items in the project. Conversely, most of the items in the total project will be of relatively minor cost significance.

In the relative cost ranking method, the items are ranked from highest to lowest in terms of total cost. Generally, potential value improvement is greatest on those items of the project with the highest total costs. Accurate cost estimates permit the relative ranking of the cost of each design element. Use the following steps:

- 1. List items of the project
- 2. Determine the cost of each
- 3. Arrange the elements in descending order, by cost

A further development of the above technique is called the ABC analysis. The ABC analysis uses a fourth step that groups the elements into cost items as A = high, B = medium, and C = low.

The ABC analysis shows high-expenditure or A parts normally represent approximately 20 percent of the total number and account for about 80 percent of the total cost.

2.4 EVALUATE VE STUDY CANDIDATES

Through the use of the above techniques, several candidate studies may be considered. Time and resources usually limit the number of studies that can be undertaken. Usually only the most promising will be chosen for complete VE review.

- A. Consider study time versus project urgency. Estimate the length of time to perform the study. The complexity of the project and the amount of readily available information on the subject will influence the length of the study.
- B. Correlate resources to tasks such as the existing VE capability. The availability of staff and other team members will determine when the study can start.
- C. Determine the probably time to implement results of the study. Factors such as the number of required changes to existing design drawings, processing contract change orders, ordering materials, and scheduling and coordinating the change all can play a part.
- D. Determine the present phase of the design life cycle. With a one-of-a-kind item, such as a bridge designed for a specified location, the earlier in the design/construction cycle a VE study is conducted, the greater the potential savings. The later in the life cycle, the cost and time to redesign will be more significant.
- E. Assess potential acceptance problems. The probability of acceptance is an important factor to consider when choosing a study project.
- F. Determine the potential return on investment. The return is a ratio of the potential savings divided by total cost of the study plus the cost of implementation.
- G. Consider projects of intense interest to management. Projects in which managers have personal interest have a better chance for implementation. Consider who will be acting on the recommendations of the study team and what their involvement is in the original design.
- H. Evaluate results of previous VE studies. What recommendations were made and what were the results of similar studies? Compare the facts of the present study and the climate for change with previous studies. These considerations offer an indication as to the probability of implementation.

2.5 RANK BY INDEX OF COST SAVINGS POTENTIAL

Although relative cost ranking can identify high-expenditure items, relative cost ranking may not be able to determine the cost-reduction potential of those items. The cost ranking may be supplemented by the Index of Cost Savings Potential. The potential for cost savings is influenced greatly by the cost of the VE study and the probability of implementation. Where cost savings is the objective of the study, a further ranking method is used.

The Index of Cost Savings Potential is computed as follows:

Index of Potential = (e.s.s. e.s.c.) x probability of implementation

Where:

e.s.s. = estimated study savings = item cost before VE, minus estimated item cost after VE in dollars

e.s.c. = estimated study cost = VE study cost plus implementation cost, in dollars.

Probability of implementation ranges between 0 - 100 percent expressed as a decimal, with 0 representing no chance of implementation and 100percent (1.0), certainty that it will be implemented. Consider the study area with the highest Index of Cost Savings Potential for the first VE effort. Use the Index as a guide. It is based on percentage return on investment but in some cases, considering total dollars may be more significant.

Prioritize the projects and choose the first study project.

2.6 SPECIFIC VE PROJECT PLAN FEATURES

- A. VE plans contain the following essential features:
 - Description of the project objectives and scope to provide study direction.
 - 2. Goals for the study with estimated savings target and project cost.
 - 3. Team members with a variety of work skills and experience to conduct the project.
 - 4. Project leader and team members.
 - 5. Time limitations for each phase of the VE Job Plan.
 - 6. Target date for formal presentation of project results.

B. TEAM STRUCTURING

Depending on the scope and time restraints for the project, VE studies can vary from a one person to a team effort and may also have several people assigned to support the team if particular skills are needed. A five persons VE team supported on a part-time basis by other elements of the

organization is usually a sufficient number. Select team members based on the following criteria:

- 1. Use employees who have had prior training in VE.
- 2. Select a project leader with appropriate VE workshop training and experience as a team member on one or more VE projects.
- 3. Select team members who have familiarity with the VE process such as a one-day VE orientation course. Include a suitable orientation if such experience is unavailable.
- 4. Identify work experience or background of the team members related to the particular project study.
- 5. Use a mix of talent to achieve different points of view. Typical team members might include a soils engineer, right-of-way specialist, materials specialist, environmental specialist, structural engineer, design engineer, landscape architect, traffic operations, maintenance, resident engineer, and an experienced cost estimator.
- 6. Include team members from popular concerns such as environment, liability, and public opinion.
- 7. Emphasize using the best talent available rather than obtaining only those who can be spared.

C. TEAM OPERATION

Each member must contribute to the study. The team leader determines each person's talent and allocate tasks to make the best use of them.

In each phase of the Job Plan, the team carries out both individual and group actions. One member can obtain and organize costs, one can analyze the specifications and identify problem areas, one can get the equipment information, etc. Each can summarize and document the information so that the team can plan, create, and act to solve the problem.

D. GATHER DATA REQUIRED FOR A VE STUDY

The following information is required for a VE Study. Most of the information is available from research done during the Selection Phase:

- 1. Complete graphic data, including drawings, sketches, photographs, and standards pertinent to the study.
- 2. Specifications and technical manuals.
- Up-to-date cost estimates for the project.
- 4. Historical data, status of design, schedules, public requirements.
- 5. Design engineer and approval authority names and contact information.

2.7 SELECTION PHASE CHECK LIST

The following areas may indicate poor value and need the majority of the VE effort:

- 1. Complex design The more complex the design, the more opportunity to improve value and performance.
- 2. Advanced state-of-the-art—Design aspects that reach beyond state-of-the-art will usually offer potential VE savings.
- 3. Design cycle. An accelerated design program will usually contain elements of over design.
- 4. Materials Critical, exotic, hard-to-get, or expensive materials add cost.
- 5. Intricate shapes Deep excavations, high embankments, and steep slopes add cost.
- 6. Components that appear to be difficult to construct.
- 7. Long hauls Excessive borrow, excessive waste, expensive construction traffic control.
- 8. Long foundation piles.
- 9. Excessive reinforcement.
- 10. Coffer dam dewatering.
- 11. Architectural embellishment.
- 12. Record seeking design longest span, highest piers, or deepest cut.
- 13. Large safety factors.
- 14. Rural curb, gutter, and sidewalk.
- 15. Specially designed components that appear to be similar to low-cost, off-the-shelf items.
- 16. Components that include non-standard fasteners, bearings, grades, and sizes.
- 17. Sole-source materials or equipment.
- 18. Processes or components that require highly-skilled or time-consuming labor.
- 19. Items with poor service or cost history.
- 20. Items that have maintenance and field operation problems.
- 21. Project costs that exceed the amount budgeted.
- 22. Standard plans in use more than 3 or 4 years.
- 23. Will a change to the existing method solve any problems or have any benefits other than cost, in such areas as

noise	reliability	aesthetics
safety	fire protection	simplification
maintainability	standardization	vibration
time	performance	air quality
quality	weight	employment rate
energy use	water quality	

CHAPTER 3 INVESTIGATION

3.1 OBJECTIVE

The objective of the Investigation Phase of the Value Engineering Job Plan is to acquire knowledge of the design to be studied and to assess its major functions, cost, and relative worth.

3.2 INVESTIGATION

- A. Collect detailed information and data.
 - 1. Gather all types of information from the best sources.
 - 2. Obtain complete, pertinent information
 - 3. Get the facts.
 - Get all available costs.
- B. Determine the functions.
 - 1. Identify and define functions.
 - 2. Classify functions.
 - 3. Determine function relationships.
- C. Determine function cost.
 - 1. Determine cost of each function.
 - 2. Determine overall cost of project.
 - Identify high-cost functions.
 - 4. Determine worth of each function.
 - a. Determine worth of each function.
 - b. Determine overall worth of project.
 - 5. Determine function value.
 - a. Determine value opportunity index for each function.
 - b. Determine overall value opportunity index.
 - c. Identify areas of poor value.
 - 6. Analyze project potential.
 - a. Review life cycle cost aspects.
 - b. Establish target costs for areas of low value.
 - c. Choose specific elements to be studied.

3.3 DISCUSSION

This phase provides a thorough understanding of the system, operation, or item under study. Complete information is essential to provide the foundation for the entire VE study. The complexity of the VE project, the amount of information available, and the study schedule will impact the level of effort devoted to the Investigation phase.

This Phase also determines the functions being performed and those that must be performed by the item or system under study. VE considers two classes of functions: the <u>use function</u> and the <u>esteem or aesthetic function</u>. The use function of a design element satisfies the need to have an action performed. The aesthetic function fulfills a desire for something more than what is needed. These two functions are not mutually exclusive and are frequently present in designs. Good value occurs when the user is provided with the needed functions and desired aesthetics for a reasonable cost.

3.4 GATHER ALL TYPES OF INFORMATION

The VE team gathers all relevant information, regardless of how disorganized or unrelated it may seem. The information must be supported by credible evidence. Where supported facts are not obtainable, expert opinions can be obtained.

The required information is seldom found in comprehensive form in one place. The motto for any VE study is "RECORD EVERYTHING." Information gathering may be subdivided into separate tasks and assigned to individual team members. Information can include:

- Physical data shape, dimensions, material, skid resistance, color, weight, density, fire resistance, weather resistance, sound absorption capability, deflection resistance, and horizontal and vertical alignment.
- 2. Methods data how it is operated, constructed, fabricated, developed, installed, maintained, and replaced.
- 3. Performance data performance requirements and actual performance needs in areas of design, operation, maintenance, safety, and utility.
- 4. Restrictions in detailed specifications concerning methods, performance, procedures, operations, schedule, and cost.
- 5. Cost data detailed cost breakdown for labor, material, and markups for both construction and other life cycle cost.
- 6. Quantity data anticipated volume or repetition uses.

3.5 THE BEST INFORMATION SOURCE

Obtain information from credible sources. Seek information from multiple sources and seek the best source for the desired information. Typical sources include:

PEOPLE SOURCES – Project managers, design engineers, operators, maintenance personnel, architects, contractors, fabricators, suppliers, expert consultants.

DATA SOURCES – Planning documents, drawings, computations, design analyses and calculations, UDOT Standard Specifications and Standard

Drawings, material lists, cost estimates, schedules, scope of work, handbooks, engineering and maintenance manuals, American Association of State Highway and Transportation Officials' Policy on Geometric Design of Highways and Streets, The Roadside Design Guide, test and maintenance reports, user feedback, catalogs, technical publications, previous study data, management information systems, conference and symposium proceedings, universities.

Be sure to keep records of the names, addresses, and telephone numbers of people contacted during the course of the study and the information they supplied.

3.6 OBTAIN COMPLETE PERTINENT INFORMATION

The type of data available will depend upon the status of the design, whether it is in Concept Phase, Design Phase, Plans Specifications and Estimate (PS&E) Phase, or under construction.

Design objectives and a statement of requirements may be all that is available early in a project cycle. For an older, standard design, data such as performance under use, maintenance characteristics, failure rates, and operational costs may be available. In addition to specific knowledge of the project, it is essential to have all relevant available information concerning the technologies involved, and to be aware of the latest applicable technical developments. The more factual information brought to bear on the problem, the more likely the possibility of a substantial cost reduction.

3.7 WORK WITH FACTS

Get specific information about the item. Work on each function individually before attempting to combine them into a single multi-functioning project. The danger in a generalized statement is that one exception can prove the statement wrong and create doubt in the validity of the entire study.

3.8 OBTAIN ALL AVAILABLE COSTS

Obtain an accurate and detailed cost estimate for each proposed design to determine the design offering the greatest cost reduction.

3.9 DETERMINE THE FUNCTIONS

An item or service is purchased because it will provide certain functions at a determined cost. If something does not perform as it is intended to, it is of no use to the user and no amount of cost reduction will improve its value.

Actions that sacrifice utility of an item reduce its value to the user. Functions beyond what is needed are also of little value to the user. Anything less than

required performance is unacceptable. Anything more than required performance is unnecessary and wasteful. Carefully define the functions to achieve the best value and to properly determine and assign costs. Many times the function an item performs is identified as a required function but this is not always true. By defining the function, required characteristics of the design are identified.

Identify functions as soon as possible to determine needs. All members of the VE study group should participate in function analysis to determine the required functions vital to the successful application of the Job Plan phases.

After the functional description has been developed, the next step is to estimate the worth of performing each required function. The determination of worth is compared against the estimate of its cost. This comparison indicates whether the study will provide an opportunity for large reductions in cost. The objective of the VE study is to develop a design that closely matches the established worth.

3.10 DEFINING FUNCTIONS

- A. Use concise language to define the functions of an item.

 Defining a function in two words, a verb and a noun, is known as two-word abridgment. The advantages of abridgement are:
 - 1. Forces conciseness
 - 2. Avoids combining functions to define more than one simple function at a time.
- B. Use modifiers to better define the functions when necessary such as:
 - 1. Adjectives: Generates electrical power
 - 2. Participles: Protects bridge deck

3.11 IDENTIFYING FUNCTIONS

Identify a function so as not to limit the ways in which it can be performed. For example, consider the operation of fastening a nameplate to a piece of equipment. Rather than the specific instruction "screw nameplate", the function is better identified as "label equipment" since attaching a nameplate with screws is only one of many ways of identifying equipment. Nameplates can also be riveted, welded, hung, cemented, or wired in place. The name may also be etched, stenciled, or stamped on the equipment, eliminating the need for a separate nameplate.

Identify how something can be used, not just what it is. For example, the function of a wire can be to conduct current, fasten part, or transfer force, depending on the design intent. The function of a box culvert can be to convey water, bridge unstable material, or convey cattle. A guardrail can impede force, deflect force, absorb force, redirect traffic, or reassure motorist.

Identifying the function in the broadest possible terms provides the greatest potential for value improvement because it gives greater freedom for creatively developing alternatives. It also tends to overcome any preconceived ideas about how the function is to be accomplished.

3.12 CLASSIFYING FUNCTIONS

Functions of items or systems can be divided into two types – Basic and Secondary.

A. BASIC FUNCTION – defines a performance feature that must be attained. It reflects the primary reason for an item or system. For example, the basic function for a screwdriver would normally be transfer torque. If the desired application was to pry open paint can lids, the function would be defined in terms of the transfer of a linear force rather than a rotational force. A clear understanding of the user's need is necessary to develop an adequate definition of the basic function.

An item may possess more than one basic function. An axe that can be used for camping has a flat head for driving tent stakes and a sharp blade for cutting firewood. A basic function defines what the axe must do.

B. SECONDARY FUNCTION – defines performance features of a system or item other than those that must be accomplished. It defines what other functions the item has. The basic function of paint is to protect surface. A secondary function is to improve appearance.

Secondary functions support the basic function. For example, a valve on a radiator restricts flow and is necessary because a hot water heating design was chosen. No valve is needed with a forced air heating system. Many times, the presence of a secondary function depends on the method chosen to achieve a basic function and if the method to achieve the basic function is changed, the secondary function may be eliminated.

3.13 FUNCTIONAL RELATIONSHIP

It is common to describe systems

- 1. In terms of function and their relationship within the next larger assembly
- 2. In terms of their components or subparts
- 3. I terms of their uniqueness.

The relative position that a system or item occupies in the scheme of the total assembly is called its level of indenture. The significance of level of indenture is that the designation of functions as basic or secondary depends upon the

indenture level. A function that exists to support the method of performing the basic function is a secondary function. When a function is considered by itself and with respect to itself, it is a basic function.

Systems and items may have many levels of indenture. The rule of functional evaluation is to work from the top, down and to consider the item or system under study as the top assembly. If the function of the top assembly is dependent upon the function of the indentured item the function of the indentured item is basic.

Table 4

Functional Relationships			
Level of Service	Component	Functions	Classification B=Basic S=Secondary
1	Fire Alarm System	Make Noise Detect Fire Protect Building	В В S
2	Person Equipment	Detect Fire Pull Lever Make Noise Transfer Sign	B S B S
3	Pull Boxes Bells Panels Conduit and Wires	Break Circuit Make Noise Provide Power Control Circuits Transmit Signal Transmit Power	S B S S S S

Table 4 illustrates the functional relationship between levels of a manually operated fire alarm system.

The defined system must perform two basic functions. Rather than choosing the restrictive function of "ring bell" the broader term "make noise" was selected to permit greater freedom in developing alternative ways of making noise such as horns, bells, or sirens.

Another approach used for identifying and classifying the functional relationships of a study subject is FAST Diagramming.

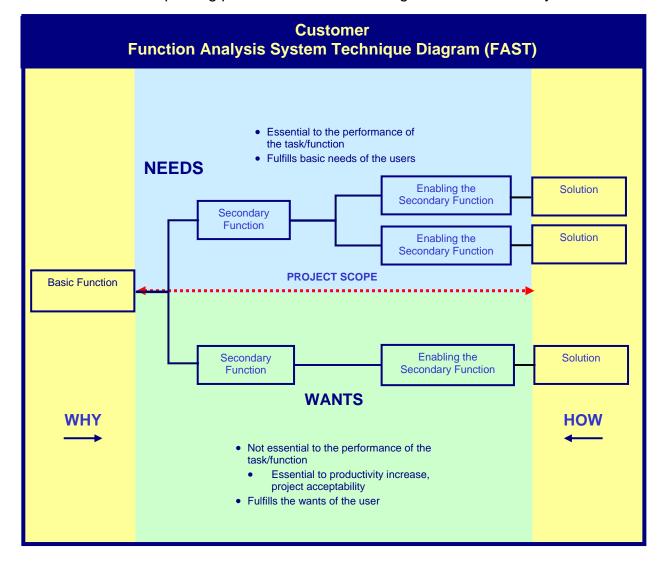
3.14 DEVELOPING A FAST DIAGRAM

In 1964, Charles W. Bytheway developed a system known as the Function Analysis System Technique (FAST). Bytheway, the Value Engineering and Cost Reduction Administrator for UNIVAC, was searching for a way to analyze the

functions of the Walleye Missile System. He presented his technique in 1965 to the Society of American Value Engineers at their National Conference in Boston. FAST diagramming has since been used in VE studies throughout the world as a tool to identify the interrelationship functions under study. A FAST diagram is best accomplished as a team effort. Involving different viewpoints causes deeper thinking and a more thorough investigation about the subject.

FAST Diagrams are used to prioritize the objectives or functions of the product. Once the objectives are prioritized the options are evaluated to determine which will return the most value based on predetermined value criteria such as:

- 1. Targeting true customer needs and wants
- 2. Delivering requirements but still enabling cost reduction by focusing on what the function accomplishes versus what the product is
- 3. Eliminating unimportant requirements
- 4. Adding incremental costs to achieve larger performance benefit
- 5. Improving performance and reducing cost simultaneously



The FAST model has a horizontal orientation described as the HOW-WHY dimension. This dimension is described in this manner because HOW and WHY questions are asked to structure the logic of the system's functions. Start with a function on the left and ask WHY that function is performed and continue to ask why as you move across the page to the right. This will create a specific approach to the function. Begin to ask HOW and move from right to left to develop the solution to a higher level.

A good rule to remember in constructing a FAST Model is to build in the HOW direction and test the logic in the WHY direction. There is essential logic associated with the FAST HOW-WHY directional orientation.

- 1. When undertaking any task it is best to start with the goals of the task then explore methods to achieve the goals. When addressing any function on the FAST model with the question WHY, the function to its left expresses the goal of that function. The question HOW, is answered by the function on the right and is a method to perform that function being addressed. A systems diagram starts at the beginning of the system and ends with its goal. A FAST model, reading from left to right, starts with the goal, and ends at the beginning of the "system" that will achieve that goal.
- 2. Changing a function on the HOW-WHY path affects all of the functions to the right of that function. This is a domino effect that only goes one way, from left to right. Starting with any place on the FAST model, if a function is changed the goals are still valid (functions to the left) but the method to accomplish that function and all other functions on the right, are affected.
- 3. Building the model in the HOW direction, or function justification, will focus attention on each function element of the model. Whereas, reversing the FAST model and building it in its system orientation will cause individual functions to be overlooked and focus on the system, leaving gaps in the system.

The vertical orientation of the FAST model is described as the WHEN direction. This is not part of the intuitive logic process but it supplements intuitive thinking. WHEN is not a time orientation but indicates cause and effect.

Scope lines represent the boundaries of the study and are shown as two vertical lines on the FAST model. The scope lines bound the scope of study or that aspect of the problem with which the study team is concerned. The left scope line determines the basic function of the study. The basic function will always be the first function to the immediate right of the left scope line. The right scope line identifies the beginning of the study and separates the input function from the scope of the study.

The objective or goal of the study is called the "Highest Order Function", located to the left of the basic function and outside of the left scope line. Any function to the left of another function is a "higher order function". Functions to the right and outside of the right scope line represent the input side that turn on or initiate the subject under study and are known as lowest order functions. Any function to the right of another function is a "lower order" function and represents a method selected to carry out the function being addressed.

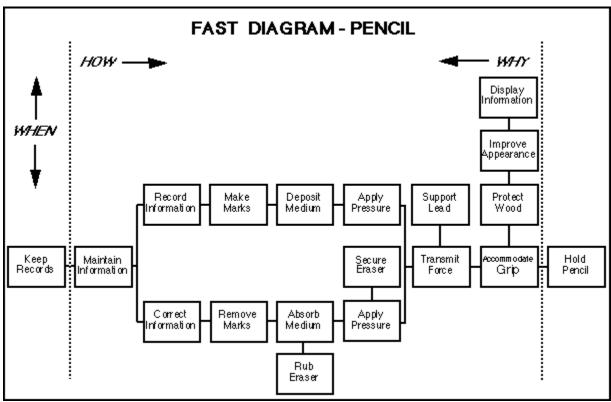
Those functions to the immediate right of the left scope line represent the purpose or mission of the product or process under study and are called Basic Functions. Once determined, the basic function will not change. The product or process will lose its market value if the basic function fails.

All functions to the right of the basic function portray the conceptual approach selected to satisfy the basic function. The concept describes the method being considered or elected to achieve the basic function. The concept can represent either the current conditions as is or proposed to be approach. As a general rule, it is best to create a "to be" rather than an "as is" FAST model, even if the assignment is to improve an existing product. This approach will give the product development team members an opportunity to compare the "ideal" to the "current" and help resolve how to implement the differences.

Working from an "as is" model will restrict the team's attention to incremental improvement opportunities. An "as is" model is useful for tracing the symptoms of a problem to its root cause and exploring ways to resolve the problem because of the dependent relationship of functions that form the FAST model. Any function on the HOW-WHY logic path is a logic path function. Functions along the WHY direction lead into the basic function and are located on the major logic path. A minor logic path does not lead directly to the basic function.

Changing a function on the major logic path will alter or destroy the way the basic function is performed. Changing a function on a minor logic path will disturb an independent or supporting function that enhances the basic function. Supporting functions are usually secondary and exist to achieve the performance levels specified in the objectives or specifications of the basic functions or because a particular approach was chosen to implement the basic function.

Independent functions describe an enhancement or control function on the logic path. They do not depend on another function or method selected to perform that function. Independent functions are located above the logic path functions and are considered secondary with respect to the scope, nature, level of the problem, and its logic path. An example of a FAST Diagram for a pencil is shown below.



Adapted from an example developed by J. Jerry Kaufman

The next step in the process is to dimension the FAST model or to associate information to its functions. FAST dimensions include but are not limited to: responsibility, budgets, allocated target costs, estimated costs, actual costs, subsystem groupings, placing inspection and test points, manufacturing processes, positioning design reviews, and others. There are many ways to dimension a FAST model. The two popular ways are called Clustering Functions and the Sensitivity Matrix.

Clustering functions involves drawing boundaries with dotted lines around groups of functions to configure sub-systems. Clustering functions is a good way to illustrate cost reduction targets and assign design-to-cost targets to new design concepts. Develop an "as is" product FAST model, cluster the functions into subsystems, allocate product cost by clustered functions, and assign target costs for cost reduction. Customer sensitivity functions can be identified during the process of creating the model as well as opportunities for significant cost improvements in design and production.

The subsystems can be divided among product development teams assigned to achieve the target cost reductions when the model is complete. The teams can then select cost sensitive sub-systems and expand them by moving that segment of the model to a lower level of abstraction. This exposes the detail components of that assembly and their function/cost contributions.

3.15 DETERMINATION OF FUNCTIONAL WORTH

Establishing worth is the most inexpensive way to perform a function. Establishing function worth begins after all functions have been identified, classified as basic or secondary, and unnecessary functions have been discarded. Determining functional worth is the most difficult and most valuable VE step. It is a highly creative endeavor and subjective rather than objective or absolute. Skill, knowledge, and judgment play a major role in determining the quantitative aspect of worth. Function worth is usually determined by comparing relative costs of alternate function methods. Attempt to find the lowest cost to perform the function.

Worth is associated with the function under consideration and not with the use of the function in the present design. For example, consider a bolt supporting a steel beam in a bridge. The worth of the bolt is the lowest cost necessary to provide any reliable fastening to support a steel beam and has nothing to do with the use of the beam in supporting a bridge.

3.16 DETERMINATION OF FUNCTIONAL COST

Functional cost is the cost to perform the function under consideration. Where an item serves one function, the cost of the item is the cost of the function. Where an item serves more than one function, the cost of the item is pro-rated to each function.

For example, if the cost of a noise barrier is \$2 per square foot, an appropriate breakdown of the cost on a functional basis is:

<u>ITEM</u>	<u>FUNCTION</u>	<u>TYPE</u>	UNIT COST
Noise barrier	Absorb sound	В	1.25
Beautify landscape		S	0.75

3.17 FUNCTIONAL VALUE DETERMINATION

Value can be quantitatively expressed through the cost to worth ratio called the Value Opportunity Index. High ratios indicate poor value. Low ratios indicate good value. The Value Opportunity Index established for a project or a function provides a measurement of its true value and suggests items or functions susceptible to value studies.

A. LIFE CYCLE COST MODEL

Maximum value is achieved when performance is reliably achieved for minimum total cost throughout the VE Job Plan. Satisfactory performance throughout the desired life cycle of the product is essential to good value. Value Engineers look beyond initial cost. The costs of operation, maintenance, disposal, or replacement must also be taken into consideration. UDOT has adopted Life Cycle Cost Analysis as the standard economic analysis tool. Refer to this manual for instructions.

Include an analysis of the following items in a complete Life Cycle Cost model and calculate in terms of present value:

- 1. Capital Cost The initial cost of construction, design, land, legal fees, etc.
- 2. Maintenance The cost of regular maintenance patrol, repair, salaries of maintenance personnel, and maintenance contracts
- 3. Rehabilitation/Replacement The cost of replacing materials, equipment, or other elements during the life cycle of the entire facility
- 4. Salvage Income derived from disposal of a facility or the value of unused service life
- 5. Miscellaneous Other factors to be considered include:
 - a. Finance Cost
 - b. Denial of Use
 - c. Lost Revenue

B. ANALYSIS OF PROJECT POTENTIAL

VE is performed when cost information has been determined, worth established for the functions, and a cost/worth ratio developed. The Value Opportunity Index is a measure of the value level of the present approach. It also measures unnecessary cost and value improvement potential. Depending on the method of function evaluation, these may measure from 2:1 up to several hundred-to-one. It is possible to establish standards of value that indicate when an index is higher than normal if consistent methods are used for function evaluation. Cost/worth ratios can be determined for certain types of functions, products, or components. A plot or chart of these ratios can identify poor value items. Value improvement is indicated if the ratio exceeds three.

Functional area analysis is another technique. This technique divides the units under study into functional areas such as clearing and grubbing, cut and fill, borrow, foundation, drainage, etc. Cost and worth are established to determine where costs seem to be unnecessarily high. A functional tree chart or block diagram of functional areas with components arranged from high to low cost provides an excellent tool for visual analysis of system costs.

Analyzing similar types of functions may indicate a potential for simplification or elimination of duplication. There may be several parts

that perform the same function or that have more costs associated with secondary functions than with the basic function.

At this point in the Value Engineering Job Plan determine if the project will be continued, certain areas within the project warrant further study, or that good value exists and no worthwhile savings can be achieved by continuing the VE Study. The objective of the cost and function analysis is to highlight unnecessary costs and establish cost targets for improved value. These targets are carried into the Speculation Phase.

C. INVESTIGATION PHASE CHECK LIST

- General
 - a. What is the item?
 - b. How does it work?
 - c. What does it do or accomplish?
 - d. Why does it work?
 - e. What must it do or accomplish?
 - f. How does it relate to other systems?
 - g. Why is it needed?
 - h. Have all of the functions been identified?
 - i. Have redundant function been identified?
 - j. Have required functions been identified?
 - k. Are functional requirements understood?

2. Specifications

- a. Have specifications and requirements been reviewed?
- b. Are specifications realistic?
- c. Can a modification of the specifications simplify design and construction?
- d. Are the specifications required or are they just guidelines?
- e. Are all performance and environmental requirements necessary and sufficient?
- f. Have all of the specifications been interpreted correctly?
- g. What are the desirable characteristics?
- h. Have State and Federal polices, procedures, and regulations been reviewed?
- 3. Engineering and Design
 - a. Has the background information been collected?
 - b. Who designed it and when?
 - c. Who determined the requirements (members of the Concept Team)?
 - d. Who must review and approve a change (the District Preconstruction Engineer or the Engineer for Design Support)?
 - e. Who must approve implementation funding (the Preconstruction Engineer and the Engineer for Programming)?

- f. Who must implement the change (the Design Engineer)?
- g. Does the design meet or exceed those set forth in the Concept Report?
- h. What alternatives were considered during design?
- i. Why were the alternatives rejected?
- j. Are any changes to the design planned?
- k. Do the drawings reflect state-of-the art?
- I. What is the design life?
- m. What are the Life Cycle Costs?
- 4. Methods and Processes
 - a. Can functions be combined, simplified, or eliminated?
 - b. Are any nonfunctional or appearance-only items required (identified in the Environmental Document)?
 - c. How is construction performed and why?
 - d. Are there any high direct labor costs?
 - e. Are high-cost areas or items identified?
 - f. What is the schedule (this is very important, because VE cannot be seen as a delaying process)?
- Materials
 - a. Are special, hard-to-get, or costly materials specified?
 - b. Were alternative materials considered and if so why were they rejected?
 - c. Are the specified materials hazardous or difficult to handle?
 - d. Are there new materials that may perform the same function?
 - e. Is this a single source item?
- Maintenance
 - a. Has the Maintenance Division, District Maintenance Engineer, and Shed Forman been consulted?
 - b. What is normal maintenance?
- 7. Function and Worth
 - a. Are costs assigned to each function?
 - b. Has a worth been established for each function?
 - c. Have target costs been determined for each function?
 - d. Are design requirements established that do not require any function to be performed?
 - e. Are functional requirements exceeded?
 - f. Are unnecessary features called for?
 - g. Can a function be eliminated, entirely or in part?
 - h. Does it cost more than it is worth?
 - i. Have all the high and unnecessary cost areas and high cost/worth ratio areas been identified?
- 8. Does the potential cost reduction (net savings) appear to be sufficient to make further VE investigations worthwhile?

CHAPTER 4 SPECULATION PHASE

4.1 OBJECTIVE

The objective of the Speculation Phase of the Value Engineering Job Plan is to "brainstorm" the functions of the design elements isolated by the investigation Phase, and to develop a number of alternatives to each.

4.2 SPECULATION PHASE OUTLINE

- A. Understand and control the positive and negative factors in creative thinking.
- B. Plan for creative sessions.
- C. Select the creative techniques to be used.

4.3 POSITIVE AND NEGATIVE FACTORS

- A. Creative thinking and brainstorming will create a variety of results. Items to consider include:
 - 1. Observation Be alert and aware of existing conditions.
 - 2. Problem Sensitivity Recognize when there is a problem.
 - 3. Constructive Discontent Question everything.
 - 4. Motivation Expend the energy and time to reach a given goal.
 - 5. Flexibility Be adaptive and open to change.
 - 6. Originality and Resourcefulness Consider new and unique ideas that reach beyond every-day solutions.
- B. There are positive factors that enhance the creative process and factors that inhibit the process. Recognize mental blocks and eliminate them. Blocks to creativity include:
 - 1. HABITUAL BLOCKS
 - a. Continuing to use or approve "tried and true" procedures when new and better ones are available.
 - b. Lack of a positive outlook; lack of determined effort, conformity to custom, and reliance on authority.
 - PERCEPTUAL BLOCKS
 - a. Failure to use all the senses of observation.
 - b. Failure to investigate the obvious.
 - c. Difficulty in visualizing remote relationships.
 - d. Failure to distinguish between cause and effect.
 - CULTURAL BLOCKS
 - a. Need to conform to "proper" patterns, customs or methods.
 - b. Over-emphasis on competition or cooperation.

- c. The drive to be practical, above all things.
- d. Having confidence and faith only in reason and logic.

4. EMOTIONAL BLOCKS

- a. Fear of making a mistake or appearing foolish.
- b. Fear of supervisors and distrust of colleagues and subordinates.
- c. Over-motivation to succeed quickly.
- d. Refusal to take any detour in reaching a goal.
- C. An important factor in creative accomplishment is environment. A creative atmosphere with respect for ability and individual thinking spurs a mind to great heights.

4.4 PLAN FOR CREATIVE SESSIONS

During this phase of the Job Plan, direct creative effort toward the development of alternative means to accomplish the needed functions. Consider alternative solutions after the problem is thoroughly understood. Participation from all members of the VE task group allows the greatest number, , best quality, and least costly alternatives.

Challenge the present method of performing the function. Technology is changing so fast that the rules of a few years ago are probably obsolete. Create new ways and alternatives to perform the necessary functions more efficiently and at a lower total life cycle cost. Take advantage of new products, processes, and materials.

Use as many creative techniques as necessary to get a fresh point of view. Adopt a positive mental approach to any problem. Allow no negative thoughts or judgments in developing ideas. Concentrate on creating as many ideas as possible on how the function can be performed. Write down all of the ideas, consider all possible combinations, and determine the best method of performing the function.

Make every attempt during this phase to depart from the ordinary patterns, typical solutions, and habitual methods. A new, fresh, and radically different approach often uncovers the best value solutions.

The best solution may be complete elimination of the present functions or item. This possibility should not be overlooked. Only after determining that the function must remain should the study group look for alternative ways to perform the same function at the lowest conceivable cost. Free use of imagination is encouraged so that <u>all possible solutions are considered</u>.

4.5 CREATIVE THINKING TECHNIQUES

Several techniques are available to the Value Engineer for use during the Speculation Phase. They may be used singularly or in combination depending on the project under study and the preferences of the team leader. Some of the more widely known and used techniques are outlined below:

A. FREE ASSOCIATION TECHNIQUES

Free association of ideas links the conscious and subconscious mind. The subconscious mind is the most creative portion of the brain but the conscious portion forms the input.

1. Brainstorming Defined

This creative approach is an uninhibited, conference-type, group approach. A typical brainstorming session consists of a group of people spontaneously producing ideas designed to solve a specific problem. The objective is to produce a number of alternative ideas for later evaluation and development.

Rules for brainstorming include:

- a. Judgmental thinking is withheld. This means controlling the natural tendency to instantaneously evaluate ideas.
- b. No criticism by word of mouth, tone of voice, shrug of shoulders or other forms of body language that indicates rejection.
- c. "Free-wheeling" is welcome. The wilder the idea, the better. It is easier to tame down than to think up.
- d. Apply the technique of hitchhiking, piggybacking, or synergism to expand on the ideas of others by offering many variations.
- e. Combine and improve ideas.
- f. Set a goal of time or number of ideas to force hard thinking.

2. Brainstorming Procedures

- a. The group has a free discussion with the group leader questioning, guiding, and occasionally supplying problem-related information.
- b. All ideas are written down all members of the group can see and hear the ideas.
- c. Use a flip chart and markers.
- d. Tape filled sheets to the walls so they are constantly in view.
- 3. Gordon Technique

The Gordon Technique is a variation of brainstorming with one basic difference. No one except the group leader knows the exact nature of the problem under consideration.

B. ORGANIZED TECHNIQUES

- 1. **The Check-List Technique** is a system of getting ideas, clues, or leads by checking the items on a prepared list against the problem under consideration. The objective is to obtain a number of general ideas to develop into a specific form.
- 2. **The Catalog Technique** is to reference various catalogs as a means of getting ideas that will create other ideas. This technique can be used as a stimulant to a brainstorming session.
- 3. **Morphological Analysis** is a comprehensive way to list and examine all of the possible combinations of ideas that might be useful in solving a problem. The procedure is as follows:
 - a. State the problem as broadly and as generally as possible.
 - b. Define the independent parameters that the solution must meet.
 - c. List all alternative ways of fulfilling each parameter.
 - d. Enter alternatives on a chart to visualize the possible combinations.
- 4. **Attribute Listing** is a technique used principally for improving a tangible thing. The procedure generally follows the four steps listed below:
 - a. Choose the object to be improved.
 - b. List the parts of the object.
 - c. List the essential features or attributes of the object and its parts.
 - d. Systematically change or modify these attributes.

C. FORCED RELATIONSHIP

These techniques operate on the principle of forcing a relationship between objects or ideas that may never have been previously associated. Synectics is one type of Forced Relationship technique. The word Synectics is from a Greek term that conveys the thought of joining different and irrelevant elements. In practice, people with diverse backgrounds are organized into a problem-solving group. Efforts are directed toward developing ideas through various techniques that make the familiar strange and the strange familiar.

One example is through the use of personal analogy or role playing, where one member of the group acts the part of the item under consideration. For instance, imagine yourself as a guardrail and list the various ways you could redesign yourself to be a better guardrail at a lower cost.

Direct analogy is another example. Here a comparison is made with other things such as plants, animals, and insects. Brunel solved the problem of underwater construction by watching a ship worm tunnel into a timber.

The worm constructed a tube as it moved forward. This led Brunel to the idea of caissons.

4.6 SPECULATION PHASE CHECKLIST

- 1. Have creative thinking techniques been used?
- 2. Has an atmosphere that encourages and welcomes new ideas been provided?
- 3. Has there been cross-inspiration?
- 4. Have all members of the team participated?
- 5. Has an output goal been set?
- 6. Have all of the ideas been recorded?
- 7. Have negative responses been discouraged?
- 8. Has the team reached for a large number of ideas?
- 9. Have ideas been generated without all of the constraints of specifications and system requirements?
- 10. Has a thorough search been conducted for other items that are similar in at least one significant characteristic to the study item?
- 11. Have all basic functions of the project been defined?
- 12. Has a speculation worksheet been filled out for each basic function?
- 13. Have you dismissed from your thoughts the present way the basic function is accomplished?
- 14. For group brainstorming, have techniques, method of approach, and "ground rules" been explained before proceeding?
- 15. Have you provided for a sufficient incubation period to permit later addition of more ideas?
- 16. Have you made provisions for a later follow-up session to evaluate and refine the ideas?
- 17. Have all of the basic functions of the project team been subjected to the complete speculation Phase?

CHAPTER 5 EVALUATION PHASE

5.1 OBJECTIVE

The objective of the Evaluation Phase of the Value Engineering Job Plan is to analyze the results of the Speculation Phase, review of the various alternatives, and select the best ideas for further expansion.

5.2 EVALUATION PHASE OUTLINE

- A. Perform preliminary screening to separate the best ideas.
- B. Evaluate the alternatives and select for development.
 - 1. Determine criteria and objectives.
 - 2. Weight the alternatives.
 - 3. Weight the criteria and objectives of the project.
 - 4. Compute numerical rating.
 - 5. Rank alternatives.
 - 6. Select the best alternates for development.

5.3 DISCUSSION

During speculation, judgmental thinking was prohibited so as not to inhibit the creative process. The ideas are now critically evaluated. Key questions can set idea evaluation criteria.

A. KEY QUESTIONS

- 1. How might the idea work?
- 2. Can it be made to work?
- 3. What is the cost?
- 4. Will each idea perform the basic function?
- 5. Which is the least expensive?
- 6. Can it be modified or combined with another?
- 7. What are the chances for implementation?
- 8. Will it be relatively difficult or easy to make the change?
- 9. Will the users' needs be satisfied?
- 10. What is the savings potential, including life cycle costs?

B. PRELIMINARY SCREENING TECHNIQUES

Several techniques are available to evaluate alternate ideas.

- 1. Comparison Technique compares various features of all alternatives under consideration.
- Advantages Versus Disadvantages Technique lists and sorts the ideas based on the number of advantages and disadvantages of each. The ideas with the greatest total advantage are selected for further evaluation.

- 3. Ranking Technique allows evaluators to assign a numerical rating to the alternates. As an example, excellent ideas are worth 5 points, good ideas worth 4 points, fair ideas worth 3 points, poor ideas worth 2 points, and very poor ideas worth 1 point. All 5-point ideas are grouped and further evaluated as are all 4-point and 3-points ideas etc. as necessary.
- 4. Probabilities Technique has evaluators assign subjective probabilities of success to the implementation of acceptable ideas. A probability close to 1 means that the idea has a good chance of being implemented. A probability close to zero means the idea has little chance of being adopted.
- 5. Estimating alternates has evaluators take the remaining ideas and rank them according to an estimate of their relative cost-reduction potential. The ranking may be based on nothing more than relative estimates comparing each of the alternates against the original design method for providing the function. The surviving alternates are then developed further to obtain more detailed cost estimates. The cost estimate for each alternate proceeds to more detailed estimates only if the preceding step indicates that it is still a good candidate.

5.4 WEIGHTING ALTERNATES

A. ALTERNATE CRITERIA METHOD

A method of graphically weighting alternates is useful when several ideas are under consideration. Ideas are rated based on appropriate criteria. To illustrate, let us assume we are studying an engine manufacturing plant that produces only a 6-cylinder in-line gasoline engine. They have discussed a large number of alternatives for the new line. These have been reviewed and four are under serious consideration.

- V8 DIESEL
- 2. V8 GASOLINE
- V6 GASOLINE
- 4. IN-LINE 4-CYLINDER GASOLINE

Standards or criteria are required in order to weight ideas. To arrive at a suitable set of criteria, ask the question "What will be affected by this idea if implemented?"

Enter the criteria in the spaces across the top of the form. List the items under consideration in the left column. Rate each item against each criteria by using 5 for superior and 1 for poor.

CRITERIA									
WEIGH ALTERNATIVES 5 SUPERIOR 4 GOOD 3 AVERAGE 2 FAIR 1 POOR	EFFECT ON:	CUSTOMERS	PLANT EQUIPMENT	SKILLED LABOR	SPACE REQUIREMENTS	VEHICLE STYLE	PRODUCTIVITY	CORPORATE	
ALTERNATIVES									TOTAL
V8 DIESEL		2	2	2	2	3	2	3	16
V8 GASOLINE		4	2	2	2	3	3	3	19
V6 GASOLINE		5	3	3	4	3	3	4	25
IN-LINE, 4 CYLINDER GASOLINE		3	3	5	5	4	5	2	27

Values are added from left-to-right and totaled in the last column. These comparisons can be used in decision making.

B. ALTERNATE OBJECTIVE METHOD

Use a set of criteria composed of specific goal objectives as a variation of the Alternative criteria method. List the specific goals across the top of the worksheet. This approach directs so a more meaningful set of standards may result.

5.5 WEIGHTING CRITERIA AND OBJECTIVES

The method most commonly used for the final selection process is that of weighting each alternative against a set of chosen criteria or objectives. Objective or criteria will rarely have equal importance.

Use a weight factor along the top of the chart. Weights from 1 to 10 can be used, with the highest number being given to the criteria with the most importance. Use 5 for superior to 1 for poor and proceed from top-to-bottom, inserting the appropriate rating in the upper left-hand portion of each divided block. Ratings are based on the degree of contribution made towards accomplishing each individual objective. Use a 5 rating for alternatives that contribute substantially towards achieving an objective. Rate a somewhat smaller contribution 4, and a poor contribution 1. Do not arbitrarily discard any ideas without an objective preliminary evaluation to determine whether or not there is some way the idea can work. A numerical rating is computed by multiplying the weight factor times

the rank. The result is inserted in the lower right-hand portion of each square. Add horizontally and post the total in the right-hand column.

OBJECTIVES CRITERIA									
 WEIGH ALTERNATIVES 5 SUPERIOR 4 GOOD 3 AVERAGE 2 FAIR 1 POOR 	CONTRIBUTION TO:	SPECIFIC FUEL CONSUMPTION	ACCELERATION FROM START	MAINTENANCE COST	WEIGHT	ORIGINAL COST	LIFE OF ENGINE	ACCESSORY POWER	
ALTERNATIVES WE	IGHT	7	4	3	2	10	9	5	TOTAL
V8 DIESEL		5 /35	1/4	2 6	2 / 4	1 10	5 / 45	5 / 25	129
V8 GASOLINE		3 / /21	5 /20	3 /9	3 6	3/30	3 / 27	5 /25	138
V6 GASOLINE		4 /28	4 /16	4 / 12	4/8	4/40	3 / 27	3 /15	146
IN-LINE, 4 CYLINDER GASOLINE		5 35	2 / 8	5 /15	5 10	5 50	2/ /18	1 /5	141

5.6 EVALUATION PHASE CHECKLIST

Have all ideas been reviewed?

Has each idea been refined to see how it can be made to meet all needed functional and physical attributes?

Have evaluation criteria been established?

Has a cost estimate been made for each feasible idea?

Has the implementation cost been estimated for each idea?

Has the time to implement each idea been considered and estimated?

Has each idea been rated according to relative merits regarding cost and other advantages or disadvantages?

Can alternates be simplified to attain further performance/cost optimization?

Have all the functions been reevaluated as to their need?

Have at least three ideas been selected as the best ideas?

CHAPTER 6 DEVELOPMENT PHASE

6.1 OBJECTIVE

The objective of the Development Phase of the Value Engineering Job Plan is to collect additional data thoroughly analyze the best alternatives selected during the evaluation phase, and prepare cost estimates and initial designs that will ensure acceptability and ultimate project implementation.

6.2 DEVELOPMENT PHASE OUTLINE

- A. Determine sources for additional information.
- B. Ascertain technical feasibility of the selected alternatives.
- C. Determine economic feasibility of the selected alternatives.
- D. Present findings in detailed change proposals.
- E. Develop implementation plan.

6.3 DISCUSSION

This phase is an objective appraisal of the lowest cost alternative methods to reliably perform the required functions. During this phase the most promising alternatives selected during the Evaluation Phase are further developed into detailed alternative design ideas. The intent is to obtain and present adequate data to management regarding design changes and costs.

The best ideas are complete and developed with the assistance of experts and specialists as required. Document all recommended design changes, materials, procedures, new forms, changes to standards and policy, costs, and implementation requirements. Select three alternatives for performing each major function based on the best value potentials. Develop each idea until enough data has been accumulated to prove the idea, then choose the best and develop it fully. Develop the next best idea enough to prove its potential. The idea initially selected as the best may be rejected by management. Have a number two idea to fall back on.

6.4 DEVELOPMENT PHASE TECHNIQUES

Use search techniques. Develop a list of names of specialists and suppliers who have the knowledge needed in proposal development using references and phone communications. Additional reference materials include:

- 1. Buyer's Guides and Catalogues
 - a. Sweet's Catalogue Service Series
 - b. Standard Manuals
 - c. Means Cost Estimating Guides
- 2. Directories
 - a. Thomas Register
 - b. State Business Directories
 - c. Phone Book Yellow Pages
- 3. Standards and Specifications
 - a. AASHTO Standards and Specifications
 - b. ASTM Standards and Specifications
 - c. State Standards and Specifications
 - d. Technical Society Standards

6.5 OTHER SOURCES

- 1. Transportation Research Board
- 2. Handbooks of Technical Societies
- 3. Trade Magazines and House Publications
- 4. General Services Administration's Value
- 5. Engineering Cross feed Bulletin
- 6. Personal Contacts
- 7. Society of American Value Engineers
- 8. Publications Value Engineering and Management Digest

Consider all possible alternate design solutions including products and materials. Consult technical and construction specialists to obtain the best design value. Use precise verbs and nouns. For example, "support weight" indicates a material specialist or structural designer can contribute.

In-person consultations with specialists are more effective than those done by telephone or mail. Effective use of specialists can remove many potential roadblocks. The Value Analyst must be able to:

- 1. Define the required functions and the cost problem
- 2. Indicate the importance and priority of the problem
- 3. Make the specialist a part of the project
- 4. Direct the specialist's efforts
- 5. Give credit for the specialist's contribution
- 6. Ask the specialist to identify other specialists or sources of assistance.

Consult the highway industry's unique group of suppliers, particularly in the structural field, including personnel with the latest information on structural shapes, pipe culverts, cements, chemical additives, etc. Recent advances in traffic control techniques include specialized electronic applications. The job of the Value Team is to find and use this type of knowledge.

Encourage suppliers to suggest alternatives, other materials, design modifications, etc. to learn from their experience. Do not demand unnecessarily stringent design requirements. Over specification may be safe and easy but it is an expensive shortcut. Solicit suggestions from the suppliers and ask what there is about the design that causes high cost. Thoroughly describe the functional and technical requirements of the project in early planning. Indicate those that are critical and those where some flexibility exists. Be aware of the services your suppliers offer and maintain an up-to-date file of new services as a potential source in future planning and design.

6.6 PROCEDURES

Consider each of following for each alternate:

- 1. Analysis to insure that the user's needs are satisfied
- 2. Technical adequacy
- 3. Construction estimates and life-cycle costs
- 4. Costs implementation including redesign and schedule changes

Develop specific alternates that stand up under close technical scrutiny and follow through to specific designs and recommendations. Prepare drawings or sketches to facilitate identifying problem areas remaining in the design. Perform a detailed cost analysis of proposed alternates to include in the final proposal.

Perform tests to demonstrate technical feasibility before the alternate is recommended for implementation. Often the desired tests have already been conducted by another agency. Ask for a report on those tests. The VE team may arrange for the necessary testing and evaluation.

Required testing should not delay approval of a proposal when:

- 1. Risk is low
- 2. Consequences of less success will involve nothing more serious than less cost saving
- 3. The element being tested involves an intangible or subjective factor
- 4. The test is normal confirmation procedure after an action is taken.

Anticipate problems relating to implementation and propose specific solutions to each. Conferences with specialists in areas such as inspection, environmental, legal, procurement, materials, and planning are helpful in problem solving. Develop a specific recommended course of action for each proposal that details the steps required to implement including who will do it and the time required.

6.7 LIFE CYCLE COSTING

The life cycle cost of a bridge, highway, car, or any other item with a service life may be defined as the total cost of ownership of the item over the service life of the item. Included in the life cycle cost is the original manufacturing or construction cost, maintenance and repair costs over the service life, operational

costs, replacement cost, cost of money, and any salvage value the item may have.

Value Analysis uses life cycle costing to evaluate the various alternatives considered in selecting the most cost effective item. The principles of Engineering Economy are applied to this selection process as a method of expressing all total ownership costs on an equal comparison basis.

To make these comparisons, equate all costs on an annual cost basis or on a present worth basis. Engineering Economics does this through mathematical equations that recognize the time value of money.

CHAPTER 7 PRESENTATION PHASE

7.1 OBJECTIVE

The objective of the Presentation Phase of the Value Engineering Job Plan is to put the recommended alternatives before the decision-makers in such convincing terms that they will accept them.

7.2 PRESENTATION PHASE OUTLINE

- 1. Anticipate roadblocks
- 2. Prepare written proposal
 - a. Summarize study
 - b. Identify expected benefits and disadvantages
 - c. Make recommendation of specific action
 - d. Suggest an implementation plan of action
- 3. Prepare oral presentation
- Sell the ideas

7.3 DISCUSSION

A Value Engineering Proposal (VEP) is a challenge to the status quo of any organization. It is a recommendation for beneficial change. The success of an individual VE Team Study is measured by the savings achieved from implemented proposals. Regardless of the merits of the proposal, the net benefit is zero if the proposals are not implemented. Presenting a proposal and guiding it to implementation often requires more effort than its actual generation.

The initial presentation of the recommendation must be concise, factual, and accurate and presented in such a manner to create a desire to implement the change. Selling the recommendation depends to a large extent on the use of good human relations. Present the recommendation in such a way as to avoid any personal loss or embarrassment to those related to the study item. Give proper credit to those who contributed and to those responsible for implementation.

The information contained in the VEP will determine whether it will be accepted or rejected. Management bases its judgment on the documentation submitted with a proposal. Provide all of the data the reviewer will need to reach a decision in the proposal and supporting documentation.

7.4 WRITTEN PROPOSAL

Always make a VEP in writing. Oral presentation of study results may supplement the written report. The systematic approach of the VE Job Plan includes the careful preparation of a written report from which a more concise oral presentation will evolve.

7.5 GAINING VEP ACCEPTANCE

A. CONSIDER THE REVIEWER'S NEEDS

Use terminology appropriate to the organization and position of the reviewer. Each proposal is usually directed toward two audiences.

- 1. Technical requires sufficient detail to demonstrate the feasibility of the proposed change.
- 2. Administrative summarize the technical details. Financial implications are emphasized. Long-range effects on policies are usually more significant to the manager than to the engineer.

B. PROGRESS REPORTS

The manager who makes an investment in a VE study expects to receive periodic reports with estimates of potential results. These reports assure top management awareness, support, and participation in the program. Seldom are managers motivated to act by a one-time exposure at the final presentation, no matter how just the cause.

C. EARLY DISCLOSURE

Early disclosure of potential changes can warn the VE Team of any objections to the proposal. This early warning will give them an opportunity to incorporate modifications to overcome the objections. If management has been kept informed of progress, the VEP presentation may be only a concise summary of final estimates, pro and con discussions, and perhaps formal management approval.

D. RELATE BENEFITS TO ORGANIZATION OBJECTIVES

The VEP that represents an advance toward an approved objective is most likely to receive favorable consideration from management. Highlight all the advantages a VEP may offer toward fulfilling organizational objectives and goals. The objective may be not only savings but also attaining some other mission-related goal.

E. SUPPORT THE DECISION MAKER

The dollar yield of a VEP is likely to be improved if it is promptly implemented. Prompt implementation depends on the approval by decision makers in each organization affected by the proposal.

F. DECISION MAKERS

Identify the decision makers and conduct all VE efforts under their sponsorship. Each VEP:

- 1. Satisfies questions the decision maker is likely to ask.
- 2. Permits decision maker to preserve professional integrity and authority.
- 3. Includes sufficient documentation to warrant a favorable decision with reasonable technical and economic risk factors

G. ADEQUATE RETURN

VE Proposals should include adequate evidence of satisfactory return on the investment. Often, current contract savings alone will assure an adequate return. In other cases, Life-Cycle or total program savings must be considered. Evidence of substantial benefits will improve the acceptability of a proposal.

H. SHOW COLLATERAL BENEFITS OF THE INVESTMENT

VE proposals often offer greater benefits than the immediate cost improvements specifically identified. Some of the benefits are collateral in nature and difficult to equate in monetary terms. The likelihood of VEP acceptance is improved when all its collateral benefits are clearly identified and completely described. Some areas are maintenance, energy conservation, aesthetics, environmental quality, and replacement cost.

I. OTHER FACTORS

- 1. Cite approval of other authorities to indicate broad organizational support.
- 2. Use supplementary material depending on the nature of the report. Simple charts, figures, and tables may be far more effective than pages of hard-to-read values, dates, and statistics. Illustrations and photos are always a welcome relief from pages of text.3. Consider the procedures used by others in evaluating the proposal. View the proposal as others will view it.
- 4. Present the facts quickly and concisely. The report tells the reviewer all they want to know about something they may not be familiar in a clear and concise manner.

7.6 THE VE WORKBOOK

Compile a workbook throughout the life of a study starting with the Investigation Phase. Maintain the workbook during the project so it will require no additional preparation during this phase. The workbook assists in Summary Report preparation and supports the team recommendations.

Record the following information in the project workbook:

- 1. Project identification
- 2. Problem summary3. Explanation of why this project was selected for study
- 4. Evaluation of the process or procedure under study
- 5. All information gathered by the group
- 6. Complete list of alternates considered
- 7. Explanation of logical alternates investigated why they were not developed further
- 8. Technical data supporting the ideas selected9. Original costs, implementation cost of the proposed alternates, and cost data supporting savings
- 10. Acknowledgment of contributors to the study
- 11. Steps to and timetable for implementing the alternates
- 12. Before-and-after sketches of the items under study

7.7 REASONS FOR VEP REJECTION

Failure to provide adequate proposal documentation is a major cause for proposal rejection, as indicated below:

A. PROJECT ADVERSELY AFFECTED

Approval authority wants to feel confident in project integrity.

B. SUPPORTING TECHNICAL INFORMATION INCOMPLETE OR INACCURATE

Provide proof of previous successful uses or tests supporting the VEP.

C. INCOMPLETE OR INACCURATE COST ANALYSIS

Credible cost information is important. A conservative cost estimate gains more favorable consideration than presenting inflated savings claims. Reveal the source of the cost estimation.

D. OTHER REASONS:

- Prior unsuccessful action to initiate or develop a similar VE proposal
- 2. Inadequate time to implement the proposal

7.8 PRESENTATION CHECK LIST

- 1. Is the need for a change clearly shown?
- 2. Is the problem defined?
- 3. Is the proposal concise?
- 4. Are all the pertinent facts included?
- 5. Are dollar savings included?
- 6. Is the VE Proposal Summary Book complete and accurate?
- 7. Have recommendations, costs, and savings been double checked?
- 8. Is the information complete?
- 9. Is back-up material available to answer questions that may be asked?
- 10. Can the use of a vu-graph, opaque projector, flip charts, or blackboard help sell your ideas?
- 11. Is a plan of action been established to implement a selected alternative?
- 12. Is the change described?
- 13. Are there pictures or sketches of before-and-after conditions?
- 14. Has the best alternate been considered?
- 15. Have all the constrains been considered?
- 16. Has the recommendation been presented to the most appropriate responsible manager or decision maker?
- 17. Is the implementation plan developed?
- 18. Have the recommendations been extended to all areas of possible application?
- 19. Has the improved Value design been considered for standard of preferred practice?
- 20. Has credit been given to all participants?
- 21. Is there enough information to make a decision?

7.9 WRITTEN REPORTS

- A. Use clear communication to convey the thoughts and ideas.
- B. Observe these ten rules of clear writing:
 - 1. Use short sentences. Long sentences make reading difficult.
 - 2. Present simple thoughts and expressions.
 - 3. Use familiar words.
 - 4. Avoid using unnecessary words.
 - 5. Put action in you verbs.
 - 6. Write the way you talk.
 - 7. Use understandable terms.

- 8. Write to the reader's experience.
- 9. Use variety in expressions.
- 10. Write to express not impress.

7.10 ORAL PRESENTATION

- A. The oral presentation is key to selling a proposal. The presentation gives the VE team a chance to be certain the written proposal is correctly understood and proper communication exists. Presentation effectiveness is enhanced if:
 - 1. The entire team is present and is introduced.
 - 2. The presentation lasts no longer than 10 minutes with additional time for questions.
 - 3. The presentation is illustrated through the use of mockups, models, slides, vu-graphs, opaque projector, or flip charts.
 - 4. The team is prepared with sufficient backup material to answer all questions during the presentation.
- B. Include the following in the oral presentation:
 - 1. Identify the project.
 - 2. Summarize the problem.
 - 3. Describe the original design.
 - 4. Present the cost of original design.
 - 5. Present results of the Function Analysis.
 - 6. Introduce technical data supporting selection of the alternatives.
 - 7. Review cost data supporting the alternatives.
 - 8. Explain advantages and disadvantages and reasons for accepting the alternatives.
 - 9. Explain sketches of before-and-after design clearly depicting proposed changes.
 - 10. Explain problems and costs of implementation.
 - 11. Estimate net savings.
 - 12. Acknowledge contribution by others.
 - 13. Summarize and suggest a meeting to discuss the proposal further.

7.11 EFFECTIVE ORAL PRESENTATION SUGGESTIONS

- 1. The group does not know the information you are presenting.
- 2. Introduce yourself and explain your position.
- 3. Identify the area of discussion using terms that will be understood.
- 4. Do not use abbreviations unless they are familiar to your audience.
- 5. Use clear and concise visual aids with a minimum of written data. Do not crowd details. Use several charts or overlays.
- 6. Keep the presentation short and do not read charts verbatim.

7.12 PRESENTATION STRUCTURE

A. The Introduction

- 1. Establish contact between communicator and group.
 - a. Exhibit personal confidence
 - b. Avoid apology
 - c. Prepare a concise opening statement
 - d. Refer to the related material
- 2. Arouse listener interest in the subject
- 3. Disclose the nature of the subject and clarify its objectives
- 4. Convince the group that the subject is important to them as individuals.

B. The Body

The material may be a regulation, procedure, or report with key points underscored. Other information may be notes keyed to visual aids, an outline, a summary, or some type of digest.

- 1. State the objective forcefully and enthusiastically.
- 2. Be brief, clear, and decisive.
- 3. Use specifics instead of broad, general statements.
- 4. Define the objective in the plan.
- 5. Organize your material logically to:
 - a. Assure more complete coverage of the subject
 - Aid in arranging proper sequence for development of ideas, understanding of principles or processes, or absorption of facts
 - c. Insure proper consideration to each essential item and eliminate irrelevant material
 - d. Provide time control
 - e. Serve as a check for relating each step of the presentation to the objective
 - f. Stimulate the confidence of the presenter

C. The Summary

- Restate the objective. Some listeners may become concerned with only a particular aspect of the subject and may have forgotten the objective.
- 2. List or enumerate briefly, in sequence, the steps covered.
- 3. Write out a specific closing statement related to the objective.
- 4. Leave the listeners with a feeling of having accomplished part of their responsibility by understanding a new idea, principle, or procedure.

7.13 MAKING THE PRESENTATION

A. Suggestion to Speakers

- Do not bluff to cover lack of knowledge. Even a well-informed speaker may get questions he or she cannot answer. Admit if you do not know the answer. Find the correct answer and inform the questioner or group later.
- 2. Do not use sarcasm or ridicule. This builds resentment and a resentful mind obstructs communication.
- 3. Do not talk down to the group. Make them feel you consider yourself fortunate to have the opportunity to share your subject with them.

B. Speech Techniques

- 1. Get their attention.
- 2. Look at and talk to your listeners.
- 3. Maintain eye contact with your listeners not with your notes, charts, blackboard, or other aids.
- 4. Keep your tone conversational. Avoid impersonal indifference in your tone. Use "you" and "we" more than "I."
- 5. Be alert to audience reaction.
- 6. Observe facial expressions.

C. Platform Presence

- 1. Position yourself so you can see each listener and each listener can see you.
- 2. Posture and body movement can be highly expressive. Be alert, relaxed, and use spontaneous movements.
- 3. Avoid hand twisting and wringing.
- 4. Do not stroll aimlessly back and forth or root yourself to one spot.
- 5. Avoid distracting mannerisms.
- 6. Be enthusiastic. Enthusiasm is contagious and stimulates eager attention by the listener.

7.14 VISUAL AIDS

Graphic illustrations can translate a large number of figures into a simple, understandable, management language. Documentation and visuals are measured very differently.

Documentation is based on detailed findings. Facts, figures, and statistics make up the documentation and should be as complete, up-to-date, detailed, authentic, organized, and indexed as possible.

Visual aids summarize the situation at a glance. Limit the number of charts, graphs, or other visuals used in a presentation and make them as simple as possible to pinpoint the highlights of the presentation. A good presentation chart gets the message across clearly in less than 30 seconds and requires little explanation.

CHAPTER 8 IMPLEMENTATION PHASE

8.1 OBJECTIVE

To rapidly and properly put approved proposals into action to achieve the proposed savings or project improvements.

8.2 IMPLEMENTATION PHASE OUTLINE

- 1. Develop an implementation plan.
- 2. Execute the plan.
- 3. Monitor the plan to completion.

8.3 DISCUSSION

The objectives of a VE study are not fully attained even after the formal presentation. The recommendations must be converted into actions. All members of the study team must maintain an active interest until the proposal is fully incorporated into the design or plans. Do not allow an approved VE proposal to die because of inaction in the implementation process. Offering assistance to the responsible authority from members of the study team is one way to keep the process moving forward.

8.4 IMPLEMENTATION INVESTMENT

Emphasize the need to provide personnel time or funds in order to save money when submitting Value Change Proposals. Include action items into the normal routine of business. Review progress periodically to check that any roadblocks that arise are overcome promptly.

8.5 EXPEDITING IMPLEMENTATION

Implement ideas by effectively utilizing the knowledge gained by study team members. Use VE team members to prepare initial drafts of documents required to revise handbooks, specifications, change orders, drawings, and contract requirements. Such drafts will help create proper translation of the idea into action and will serve as a baseline to monitor progress.

8.6 IMPLEMENTATION PHASE CHECKLIST

- 1. Are the expected results known?
- 2. Has someone been designated to take action to implement the approved alternatives?
- 3. Has the contract been amended?
- 4. Have the specifications or drawings been revised?
- 5. Have implementation completion dates been established?

- 6. Have implementation resources been recommended and allocated?
- 7. Have required test plans, allocations, and schedules been established?
- 8. Have modifications to the VEP been documented?

CHAPTER 9 AUDIT PHASE

9.1 OBJECTIVE

The objective of the Audit Phase of the Value Engineering Job Plan is to check that desired results have been attained, documented, and reported.

9.2 AUDIT PHASE OUTLINE

- 1. Perform an audit
- 2. Evaluate results
- 3. Prepare final project report
- 4. Distribute information to interested parties

9.3 DISCUSSION

Records on the project cannot be closed until audit of results are completed. An audit requires additional effort, time, money, and energy. The audit process is essential to the success of the VE program.

9.4 PROCEDURE

The following steps will help the success of VE efforts:

- 1. Obtain copies of all completed implementation actions.
- 2. Compare results with original expectations to verify the accomplishment.
- 3. Submit cost savings reports or other improvements to management.
- 4. Distribute information to all interested parties and other highway agencies.
- 5. Review the project to identify problems and recommend corrective action for the next project.
- 6. Initiate recommendations for potential future VE study ideas
- 7. Recognize VE study contributors and make recommendations to management.
- 8. Determine the effect on maintenance and other life cycle costs.

9.5 ACCOMPLISHMENT

Management designates the person to complete this phase of the Job Plan.

9.6 AUDIT PHASE CHECKLIST

- 1. Did the idea work?
- 2. Was money saved?
- 3. Was the design improved?

- 4. Can it benefit others?
- Has it had proper publicity and distribution? Should any awards be made? 5.
- 6.

CHAPTER 10 HUMAN RELATIONS

10.1 GOOD HUMAN RELATIONS

Maintaining good human relations is essential. People at all levels in an organization are involved in the total VE effort. All of these people must cooperate and become part of the dynamic and creative spirit that is basic for the VE program to be successful. The way team members conduct themselves in dealing with others is one element in the success or failure of the study.

The Value Specialist will challenge team member answers and question their ideas. He or she will be critical of the status quo and seek to make constructive changes.

This chapter deals with identifying some of the causes for problems in human relations. There are three types of interactions between people involved in a VE study that are important to consider:

- 1. Relations between VE study team members including people from a number of different disciplines with differing viewpoints.
- 2. Contacts between members of the VE study team and their sources of information such as design engineers, estimators, construction engineers, and users.
- 3. Contacts with people who have the authority to approve or disapprove the changes recommended by the VE team.

10.2 PRINCIPLES OF SOCIAL BEHAVIOR

- A. Develop favorable attitudes for and acceptance of a new concept. Each team member can make an important contribution toward gaining acceptance of VE in his or her organization by following the general principles of social behavior described below:
 - 1. EMPATHY Use empathy in dealing with other people. Place yourself in another's shoes and trying to view the problem as they do. Ask yourself the following questions:
 - a. What are they saying?
 - b. What do their actions indicate?
 - c. What do they really believe?
 - d. Why do they believe this way, act as they do, and say what they do?
 - e. Are they under pressure?

Answering these questions will help you understand others. Empathy paves the way for selecting the correct approach to whatever attitude is encountered.

2. HONESTY – VE study team members contribute time and technical ability to the VE effort with no praise or recognition for their

- contributions. Always give credit to contributors of a successful VE study. When asking for help and information, admit unfamiliarity and inform the person that their efforts are appreciated.
- 3. INDIVIDUALITY Remember that every person has their own ideas, habits, and ways of thinking. Approach people as individuals and not as stereotypes. Each design is a product of a designer's sensitivities and preconceived ideas. The cooperation that we receive from others is dependent to a large degree on our ability to convince them that their competence is recognized.
- 4. THOUGHTFULNESS Regard for the feelings or circumstances of others is essential to establishing a climate where people will take an active interest in the performance of VE. Keep in mind that people have pride in their abilities and in the work they perform. It is each team member's personal job to get people to relax and lose their apprehension of those who come to them asking questions and suggesting changes. People are committed to established ways of thinking and established ways of doing things, and they don't change easily. Expecting them to adopt new ideas and philosophies in a short time is not reasonable. Patience is a vital asset if constructive results are to be realized.
- 5. POSITIVE THINKING Positive thinking can lead to positive and dynamic actions. VE team members must be well grounded in the basic VE technique so that they are able to show confidence in the techniques application. Such a positive approach must be tempered by consideration of the human relations points made in the above and following paragraphs.
- 6. TACT Be sure to reference the original design when proposing a change to someone that affects something they did earlier.
 - a. Ask about the background on the project.
 - b. Discuss ideas.
 - c. Supply new facts and data.
 - d. Ask their opinion to see if they can come up with an alternative.
- 7. FLEXIBILITY VE team members must be flexible in their thinking so that a new idea will be given full consideration and a fair decision rendered. Recognize that circumstances do change and an excellent VE proposal today might be outdated tomorrow.

A change recommended to save money may indicate that the old way is uneconomical or represents poor value. The original decision-makers may feel that change is a criticism, effects their opportunities for advancement, or decreases their esteem in the eyes of peers. These reasons may cause a lack of cooperation or disapproval of the change.

10.3 RESISTANCE TO CHANGE

Resistance to change can significantly impact a VE effort. Resistance to change usually occurs when people try to insulate themselves from the impact of the change. The intensity of the resistance depends largely on the extent to which the Value Engineer has identified and anticipated possible kinds of resistance. Some conditions that may exist for those affected by the change include:

- 1. They feel that their personal biases are being disregarded
- 2. They see an entirely different meaning in the change
- 3. They have had no say in developing the change
- 4. They are torn between logic and loyalty
- 5. They realize their vested interests are in jeopardy
- 6. They cannot understand the nature of the change
- 7. They see no benefits to the change

10.4 PROMOTE COOPERATION

Attention to human relations must be a continuing effort. Some useful rules of conduct for the VE team members are:

- 1. Acquaint people with the nature and objective of the project.
- 2. Promote VE as a team effort to achieve design excellence.
- 3. Respect the chain of authority, organization customs, and personal characteristics of the people with whom you are working.
- 4. Anticipate likely adverse reaction to your work.
- 5. Make suggestions, recommendations, and requests as clear as possible at all times.
- 6. Make reports as clear and accurate as possible.
- 7. Never start conversations by criticizing or belittling others work.
- 8. Do not imply criticism or affect jobs or assignments when handling or making proposals.
- 9. Use facts to back up the proposal or report and present them clearly.
- 10. Consult with those who are affected by proposed changes.
- 11. Listen carefully to what people say and respond to their thoughts and needs. The person who objects to a proposal may give clues to how it may be approved or modified to enable approval.
- 12. Show respect for the opinions of others.

10.5 WIN THE WAR

Good human relations on the part of the VE team will develop enthusiasm for the VE program. On some occasions the team's best efforts are unable to secure a good reception for a proposal. Attempting to force a proposal runs the risk of creating permanent hostility. Do not win the battle and lose the war. Compromise is also a good technique.

10.6 SUMMARY

There may be a number of excellent technical reasons for not implementing a change proposal. It is up to the Value Engineer to analyze the reasons. VE is often considered an unnecessary luxury that hinders job performance job. VE is a valuable service available to management and promotes the importance of program teamwork. Effective Value Engineers must be able to see the big picture and see the problem through the eyes of management. Value Engineers also become a sales person, psychologist, opportunist, and student of human nature. Value Engineers must be sincere in their belief that the VE proposal will result in improved designs at a more reasonable cost.

CHAPTER 11 VALUE ENGINEERING CHANGE PROPOSAL

11.1 INTRODUCTION

UDOT established a Value Engineering incentive clause in its construction contracts in 1989. UDOT did not receive its first VECP until 1993 when upper management began promoting VE.

The VECP is included in all new UDOT construction projects. This provides an incentive for the Contractor to initiate, develop, and present to UDOT, any conceived cost reduction proposals. This can include changes in drawings, design, specifications, or other contract requirements. The cost is paid directly for changes in quantities or new items. UDOT pays 50 percent of the savings between the cost of the revised work and the cost of the related construction under the original contract.

11.2 PROCEDURES

The basic steps required to administer a VECP (Specification 104.20, Value Engineering Proposal by the Contractor) are:

- 1. Contractor submits duplicate Formal or Preliminary VECP to both the Resident Engineer and Value Engineers Office (VEO).
- 2. Resident Engineer reviews proposal and contacts VEO to confirm receipt and decides when it will be completed.
- 3. VEO receives proposal in the format specified in 104.20.2.
- 4. VEO determines if the proposal is preliminary or a formal VECP. Submit the Formal Proposal containing all required information and the first sub-section for the Preliminary Proposal.
 - a. Review for compliance
 - b. Evaluate math quantities, reasonable cost, accuracy of bid items, bid history etc.
 - c. Determine which specialty engineering groups are required.
 - d. Discuss project with the specialty groups and the Deputy Construction Engineer.
 - e. Estimate effort required for review and compare it to the savings.
- 5. Resident Engineer invites the Contractor to present a proposal to the VE team and specialty engineering groups6. VEO determines the overall feasibility of the proposal.
- 7. VEO rejects the proposal and requests a revision if the project is not feasible or there is not an acceptable cost to saving ratio.
- 8. Advise Contractor to proceed with a Formal Proposal once the preliminary has been accepted. The VEO will select specialty Engineers and an FHWA representative to make up the VE Team

- (VET) to review the proposal FHWA will only have an advisory roll if the project is not Federally funded.
- 9. VEO will head the team, distribute the VECP, and meet with the team to determine if the proposal will work. The team will evaluate if the proposed project, is safe, if the service life be adequate, does it affect the appearance adversely, and future maintenance concerns, and is the cost reasonable.
- 10. Upon completion of the review the VET makes one of three recommendations:
 - a. Request revisions
 - b. Reject the proposal
 - c. Approve the proposal
- 11. VEO prepares a summary for the Deputy Construction Engineer, including special conditions, restrictions, etc.
- 12. The Deputy Engineer and Resident Engineer uses the VET recommendation to make their decision to accept or reject the VECP.
- 13. The Construction division notifies the VEO and the Contractor if the VECP is approved pending construction change order. The VEO notifies FHWA if there are federal funds involved.
- 14. Calculate actual savings based on construction change orders.

 Prepare a follow-up summary of VECP and send a copy to affected units.

